

# 2021 IBC Essentials

Based on the 2021 International Building Code® (IBC®)



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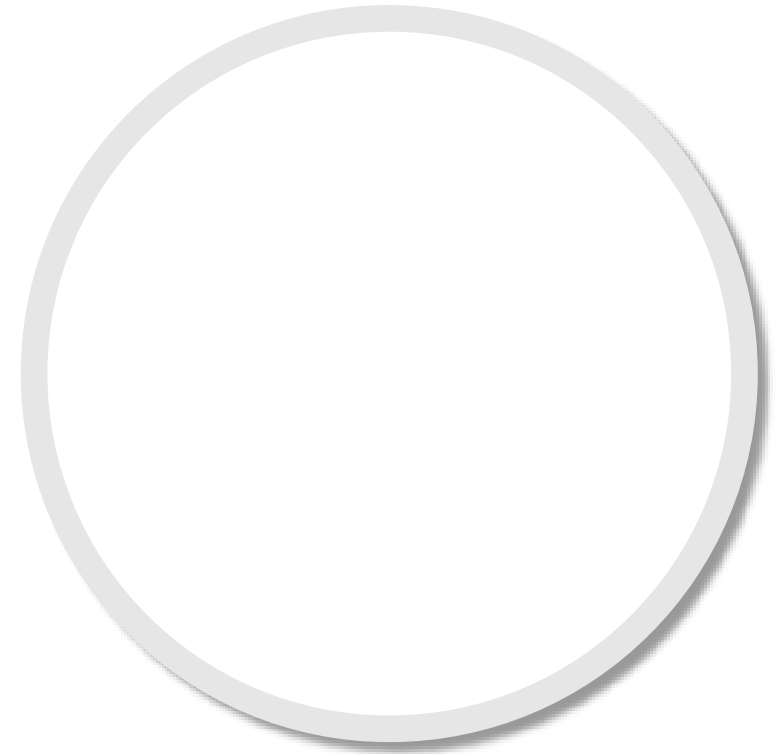
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## Instructor Name

- About You Bullet 1
- About You Bullet 2
- About You Bullet 3
- About You Bullet 4
- About You Bullet 5
- About You Bullet 6
- Your email address





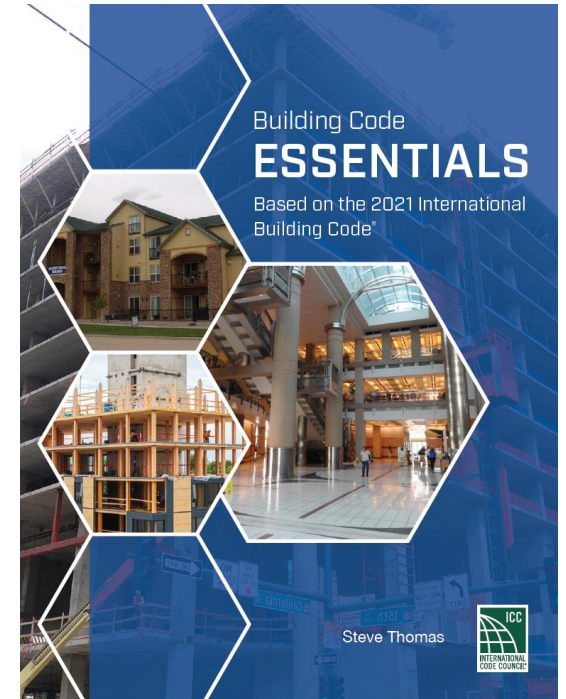
# Goal

**By the end of this learning you will be able to, apply the critical concepts and provisions of the 2021 *International Building Code*®**



# Why Does This Matter?

- This seminar focuses on 2021 IBC essential concepts
- Concepts provide a basis for correct code utilization
- Clear understanding of identified requirements allows code users to
  - Apply the IBC in specific situations
  - Build understanding of the code intent when asked to make code compliance judgments



## To achieve this goal you can.

- Explain fundamental 2021 IBC provisions and intent
- Describe common provisions applicable to commercial building design
- Comprehend passive and active fire protection
- Identify how life safety and egress issues are addressed in design and construction
- Identify occupant health and safety safeguards with weather protection and interior environment controls



# Keys to a Successful Class

1

Slides contain some text and iconic images to help you learn

2

Text and commentary is in the handout

3

Follow along in the course handout

4

Ask Questions, ask questions, ASK QUESTIONS!!!!



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# COURSE OUTLINE

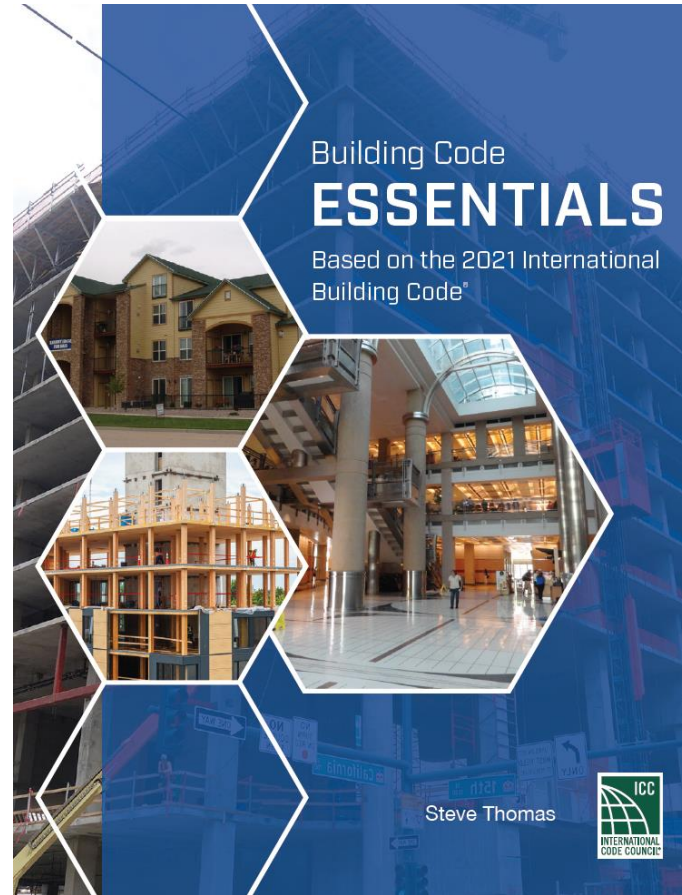
- Administration
- Building Planning
- Fire Safety
- Life Safety
- Health Safety
- Structural Safety



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# Underlying Curriculum

## COURSE BASIS



# Code Administration and Enforcement

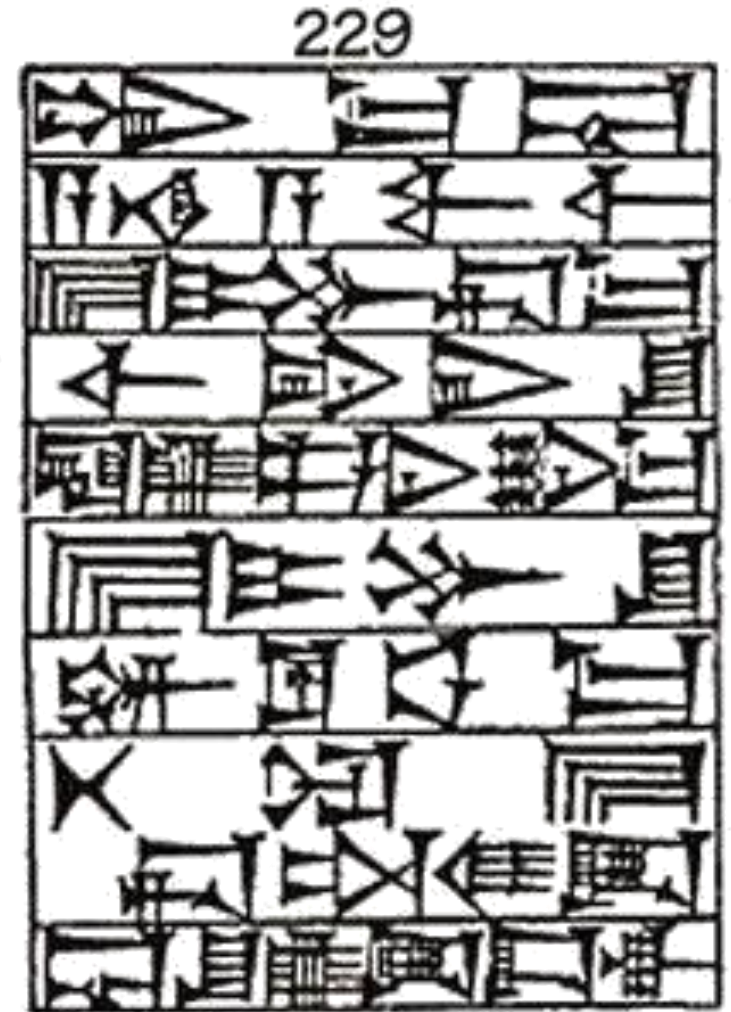


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# History of Building Codes

229. “If a builder has built a house for a man, and has not made his work sound, and the house he built has fallen, and caused the death of its owner, that builder shall be put to death.”



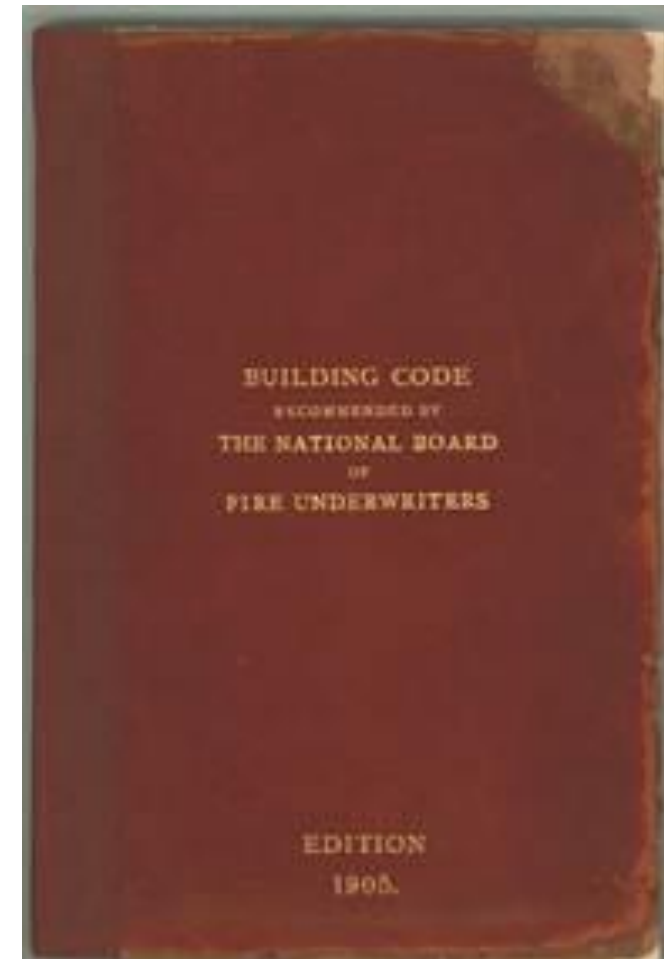




# U.S. Building Code History

## Building Code Recommended by National Board of Fire Underwriters

- Published in 1905
- One of earliest U.S. model building codes



# U.S. Building Code History

By the end of the 20<sup>th</sup> century there were 3 model building code groups

- Building Officials & Code Administrators International (BOCA)
- International Conference of Building Officials (ICBO)
- Southern Building Code Congress International (SBCCI)



# U.S. Building Code History

In 1994, BOCA, ICBO and SBCCI agreed to develop one model code

- Together formed International Code Council (ICC)
- First *International Building Code* by ICC published in 2000



# Purpose of Building Codes

- Regulations adopted by governmental agencies to ensure that buildings are built in a safe manner
- People expect when entering a building to be safe from inherent dangers caused by natural or man-made disasters



# ICC Code Development

Family of “I” Codes revised and published every 3 years

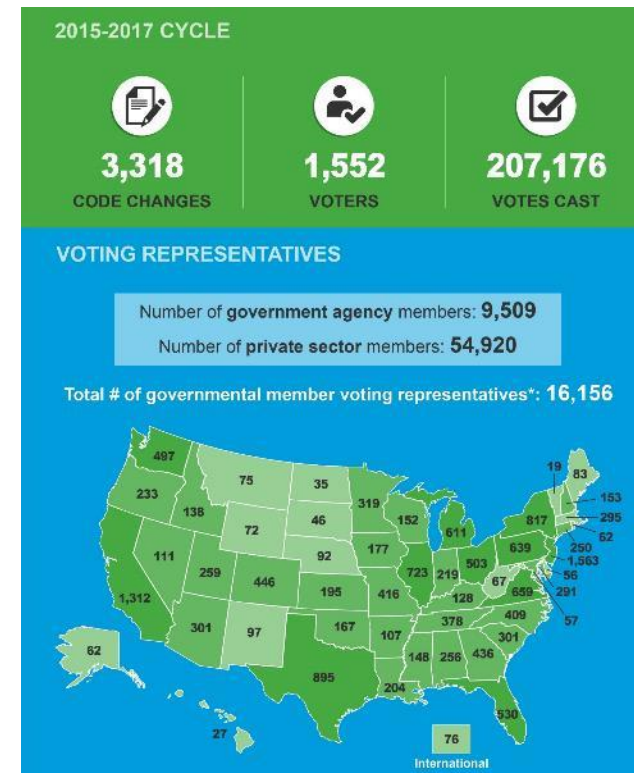
- Updated with constantly evolving
  - Construction technology
  - Methods
  - Materials
  - Equipment
  - Processes



# ICC Code Development

Revised through open “Governmental Consensus Process” which provides for:

- Openness
- Transparency
- Balance of Interests
- Due Process
- Appeals Process
- Consensus





# ICC Code Development

## STAGE ONE



### CODE DEVELOPMENT COMMITTEES

Anyone can apply to serve on one of the committees that preside over the Committee Action Hearings (CAH).

The Codes and Standards Council makes recommendations based on these applications to the ICC Board, which appoints members to the committees.

Members of each committee fall into one of three interest categories:

- **General:** government regulatory agencies.
- **User:** building owners, designers, insurance companies, private inspection agencies, academics.
- **Producer:** builders, contractors, manufacturers, distributors.



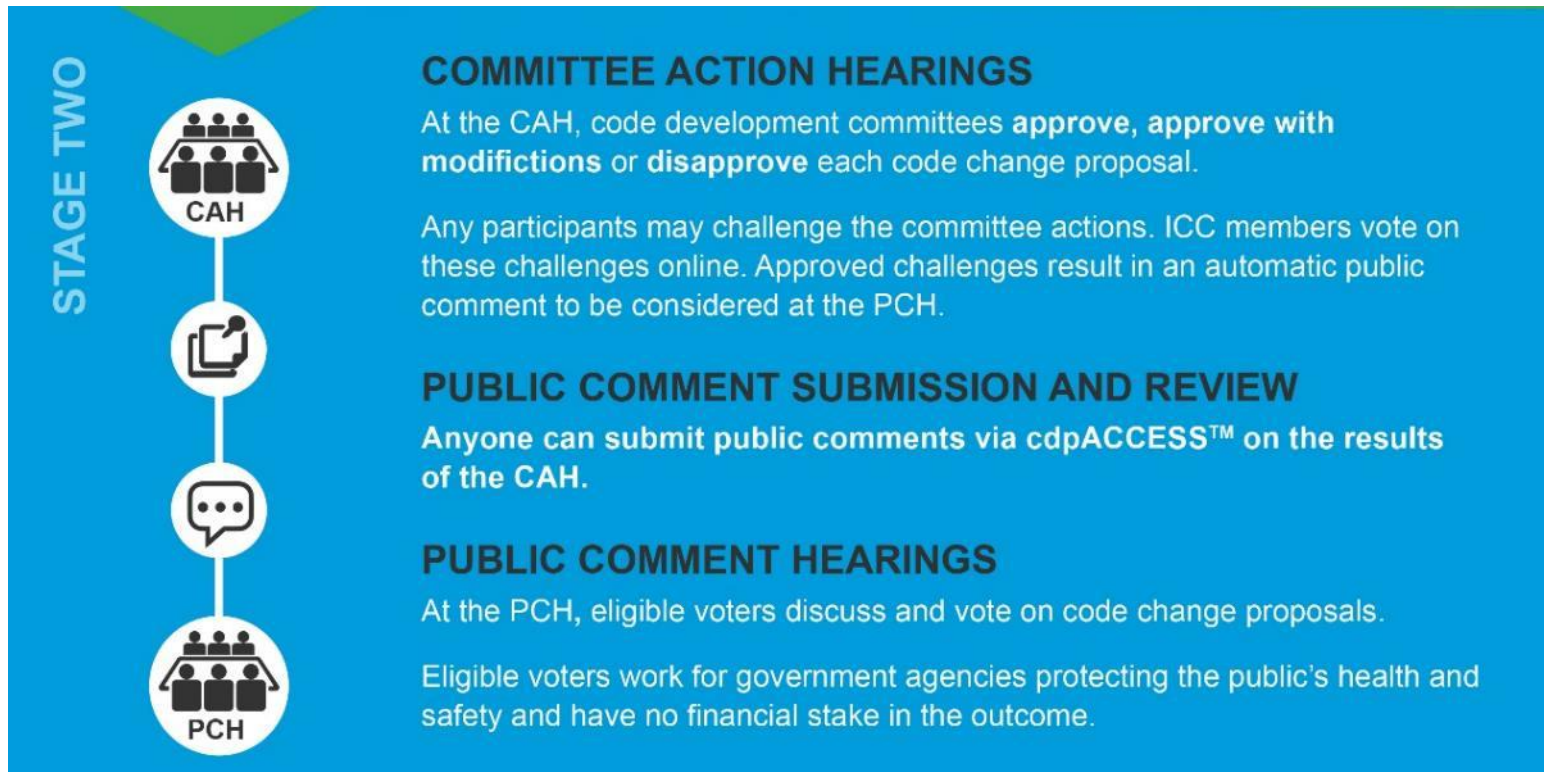
### CODE CHANGE SUBMISSION AND REVIEW

Anyone can submit code change proposals via ICC's cloud-based program, cdpACCESS™.

ICC staff reviews each proposal and assigns them to the applicable Code Development Committee.



# ICC Code Development



# ICC Code Development

## STAGE THREE



### ONLINE GOVERNMENTAL CONSENSUS VOTE

Following the PCH, eligible voters vote online. **The final vote count combines the in-person PCH and online votes.** The Validation Committee reviews and the ICC Board confirms the final results.

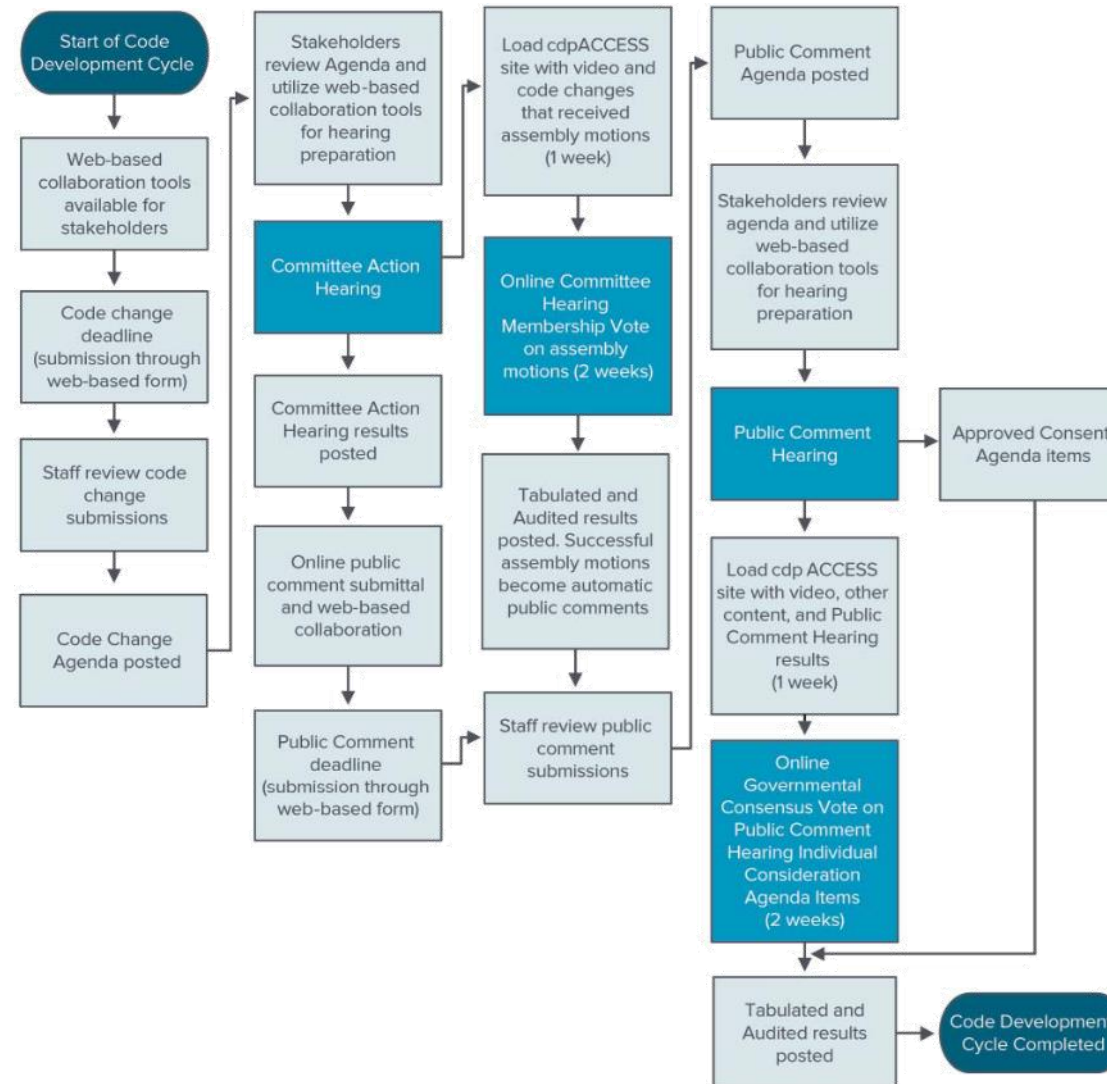


### NEW EDITION PUBLISHED

An updated edition of the International Codes is published every three years.

The Code Council also develops a number of codes and standards, including mechanical, plumbing, structural, resilience, accessibility and green standards, and is accredited by the American National Standards Institute as a standards developer.

# ICC Code Development



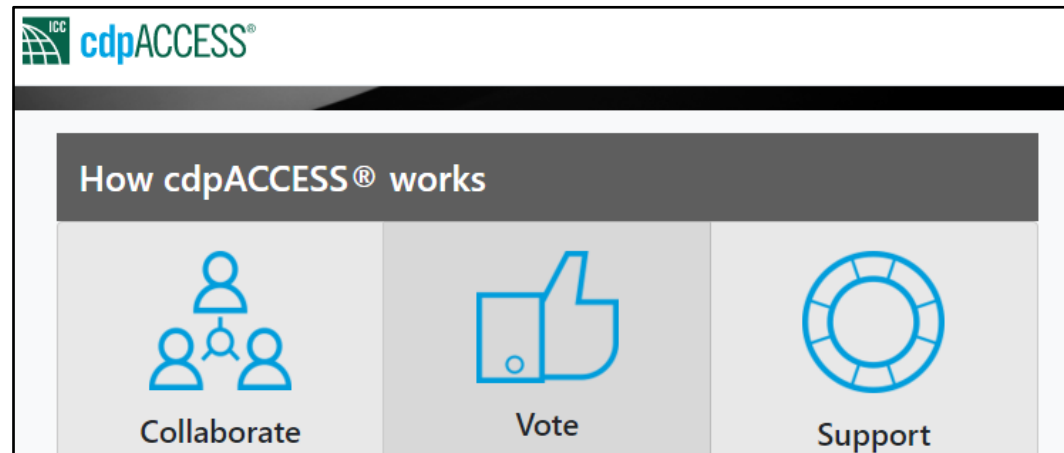
# ICC Code Development

- New code published every three years
- 12-month cycle
- Codes divided into 2 groups
  - A. IBC, IPC, IMC, IFGC, IPSDC
  - B. IRC, IFC, IEBC, IECC, IPMC, ISPSC, IWUIC, IZC, ICCPC, Admin.



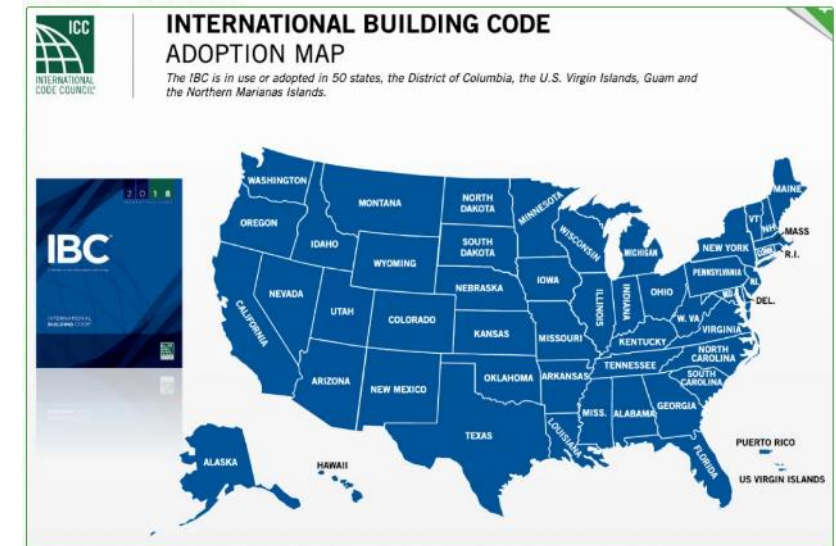
# cdpACCESS

- Cloud-based system for code development process (cdp)
- Developed to increase participation
- On code change proposals & public comments users can
  - Create
  - Collaborate
  - Review
  - Submit
  - Vote (if eligible)



# Code Adoption

- IBC is a “model” code
  - Can be adopted by governmental agency and become law
  - Adopted by federal, state and local government agencies
  - Adopted through legislation or delegate to a board or state agency
  - Adopting legislation or ordinance is required to go through a public hearing process
  - Many jurisdictions develop amendments to model codes



# Code Adoption

- Sample adoption ordinance included in all I-codes
- Jurisdiction must adopt a specific code edition
- Any appendix must specifically be adopted
- Code official is responsible for assuring substantial compliance with the adopted code and any state laws dealing with construction issues

## **SECTION 101 SCOPE AND GENERAL REQUIREMENTS**

**[A] 101.1 Title.** These regulations shall be known as the *Building Code* of **[NAME OF JURISDICTION]**, hereinafter referred to as “this code.”



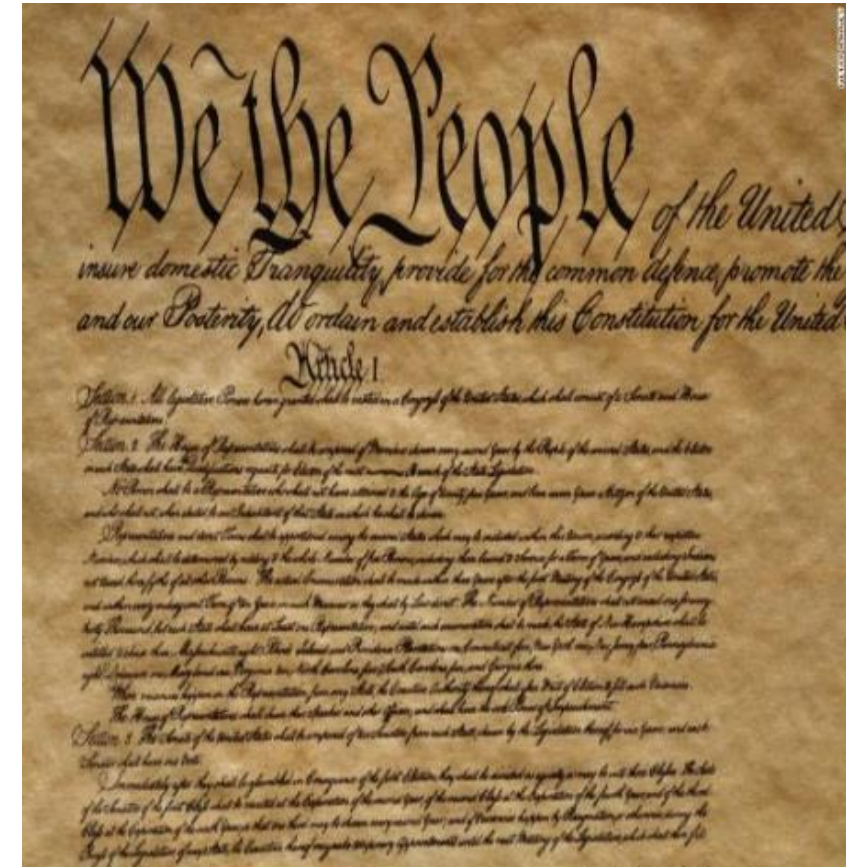
# Code Adoption

## U.S. Constitution creates

- States that have constitutions that create
  - Legislatures that pass laws signed by governors that create
  - Local governments that pass ordinances

## 10<sup>th</sup> Amendment to U.S. Constitution

- States granted authority to adopt laws to protect health, safety, morals and general welfare of its citizens
- Known as ***“Police Powers”***

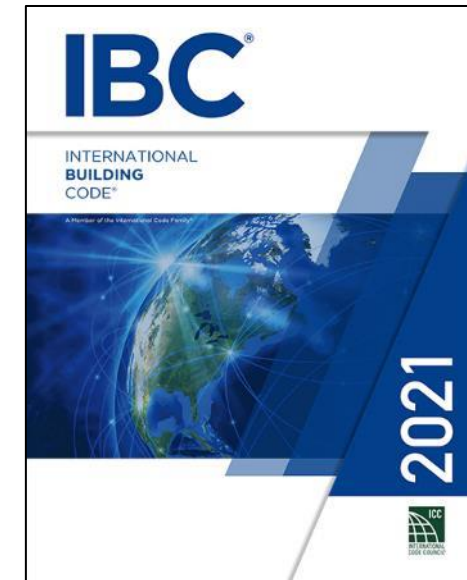




# International Building Code

## Applies to every building, structure or appurtenance

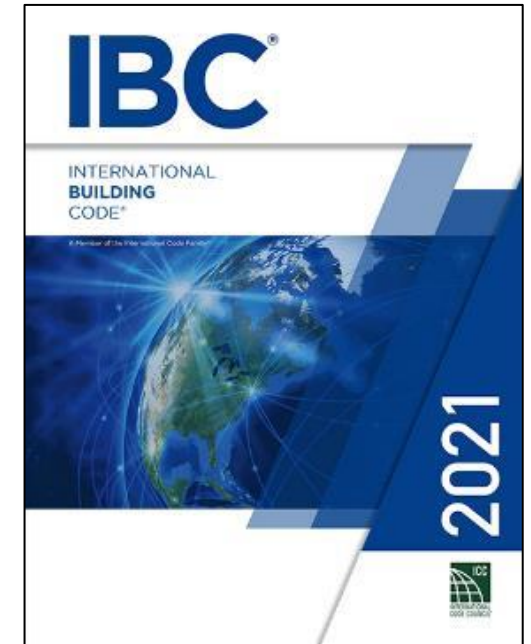
- Construction
- Alteration
- Movement
- Enlargement
- Replacement
- Repair
- Equipment
- Use and Occupancy
- Location
- Maintenance
- Removal
- Demolition



# International Building Code

## Minimum requirements for safety, health and general welfare

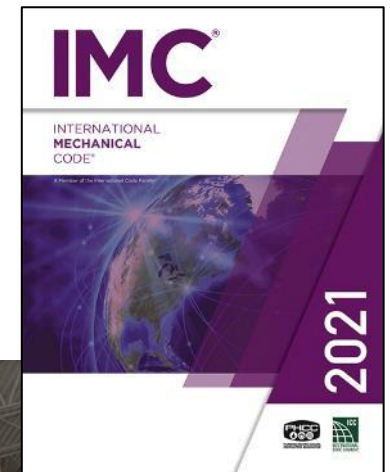
- Structural strength
- Means of egress facilities
- Stability
- Sanitation
- Light and ventilation
- Energy conservation
- Safety to life and property
  - Fire
  - Explosion
  - Other hazards



# International Building Code

## Minimum requirements for safety, health and general welfare

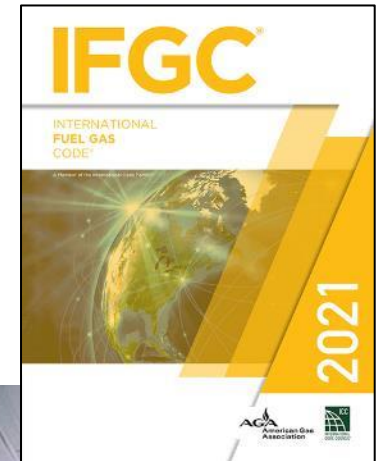
- Applies to design, installation, maintenance, alteration and inspection of permanent mechanical systems installed within buildings
- Covers
  - Heating
  - Ventilation
  - A/C systems



# International Fuel Gas Code

## Minimum requirements for safety, health and general welfare

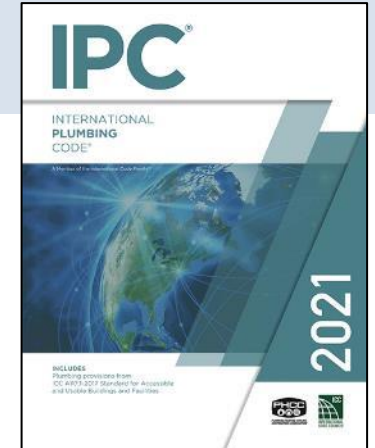
- Regulates design, installation, maintenance, alteration and inspection of appliances that utilize natural gas and liquefied petroleum gas (LPG), gaseous hydrogen systems, and related accessories



# International Plumbing Code

## Minimum requirements for safety, health and general welfare

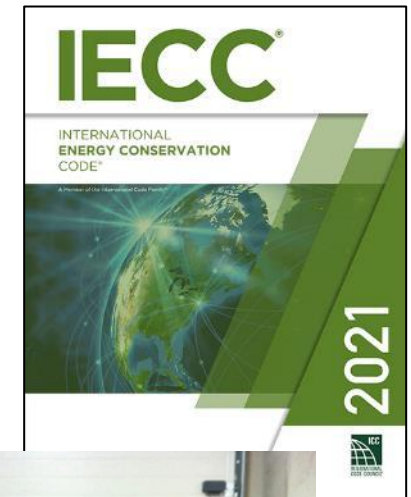
- Provides regulations for design, installation, alteration and maintenance of plumbing systems
- Governs materials, sizing and installation of potable water supply and distribution plumbing fixtures, drain-waste-vent piping (DWV) and storm drainage systems



# International Energy Conservation Code

Regulates energy use in buildings

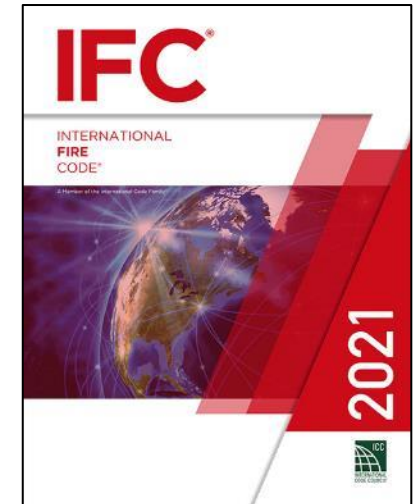
- Provides requirements for insulation R-values and door and window insulation requirements, as well as air infiltration limitations
- Applies to all buildings that are either heated or cooled





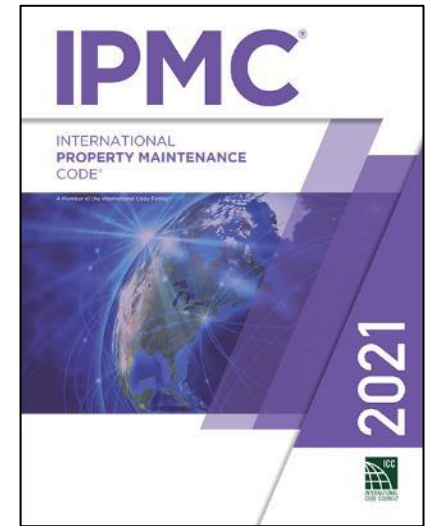
# International Fire Code

- Provides a reasonable level of life safety and property protection from hazards of fire, explosion or dangerous conditions in new and existing buildings and structures
- Provides regulations for safety of fire fighters and emergency responders during emergency operations



# International Property Maintenance Code

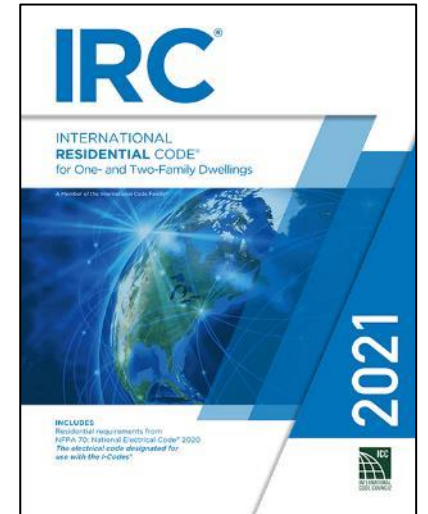
- Provides for maintenance of existing buildings and properties
- Provides minimum requirements for premises, structures, equipment, and facilities
- Addresses lighting, ventilation, space, heating, sanitation, life safety, and safety from fire and other hazards and for safe and sanitary maintenance





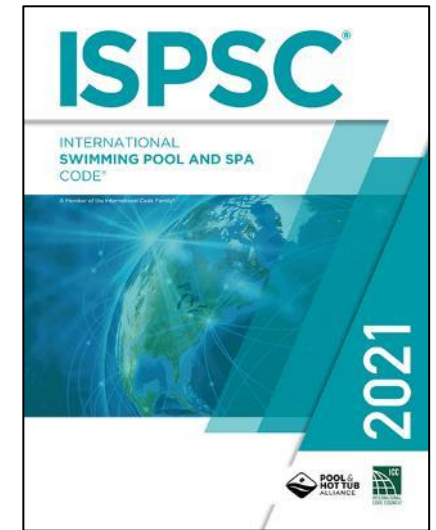
# International Residential Code

- Regulates construction of 1- and 2-family dwellings and townhouse structures
- Designed to be completely stand-alone code for residential construction
- Combines all regulations for building, energy, mechanical, fuel gas, plumbing and electrical into one document



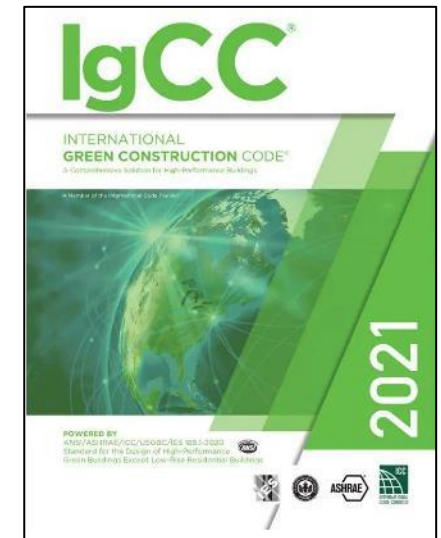
# International Swimming Pool & Spa Code

- Comprehensive swimming pool code
- Developed with the Association of Pool & Spa Professionals (APSP)
- Coordinated with requirements in
  - International Codes
  - APSP standards
- Establishes minimum regulations for public and residential pools, spas, and hot tubs



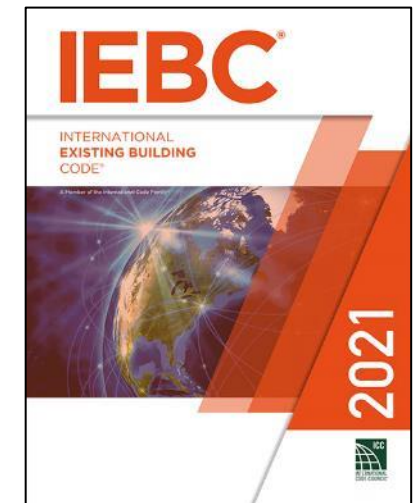
# International Swimming Pool & Spa Code

- Intended to safeguard the environment, public health, safety and general welfare
- Establishes requirements to reduce negative potential impacts on the natural environment
- Works to conserve natural resources, materials and energy



# International Existing Building Code

- Covers alteration, addition, repair, relocation or change of use of an existing building
- 3 methods that an owner can choose to show compliance with the codes
- Address work done and how codes are applied to historic buildings without affecting historical significance and character



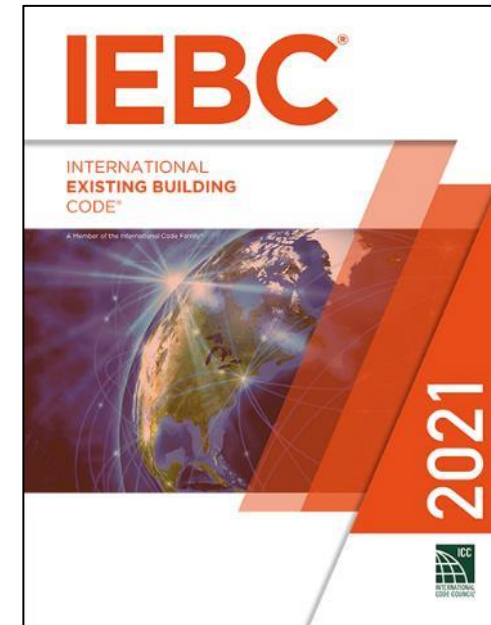
# Existing Buildings

- Existing buildings are permitted to continue without change if maintained in accordance with the code under which constructed



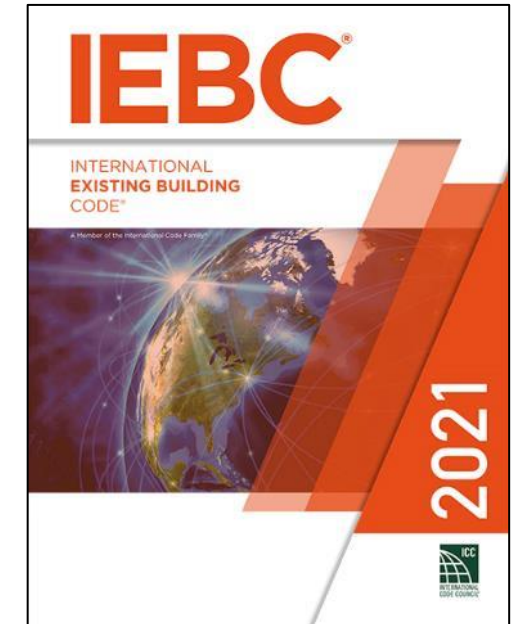
# Existing Buildings

- IBC requires work to existing buildings comply with IEBC



# Existing Buildings

- IEBC provides 3 compliance methods for owners
  1. Prescriptive
  2. Work area
  3. Performance
- Each addresses repairs, alterations, additions and change of occupancy





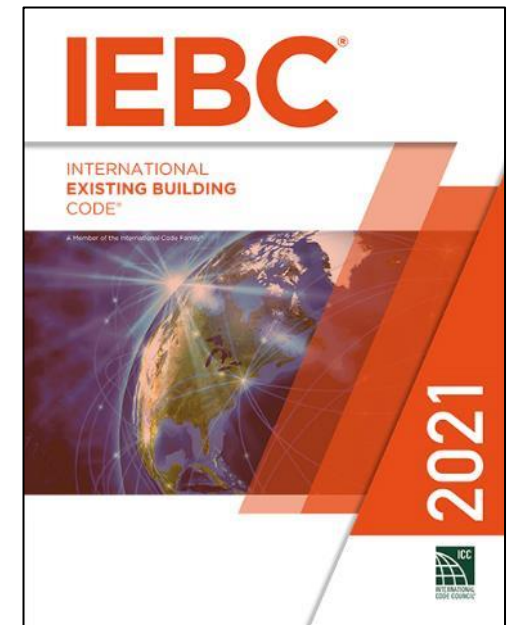
# Prescriptive vs. Performance

- *Prescriptive* Compliance

- New work must comply with current code
- Building official can
  - Require dangerous conditions corrected
  - Approve without current code compliance if new use is less hazardous than existing use

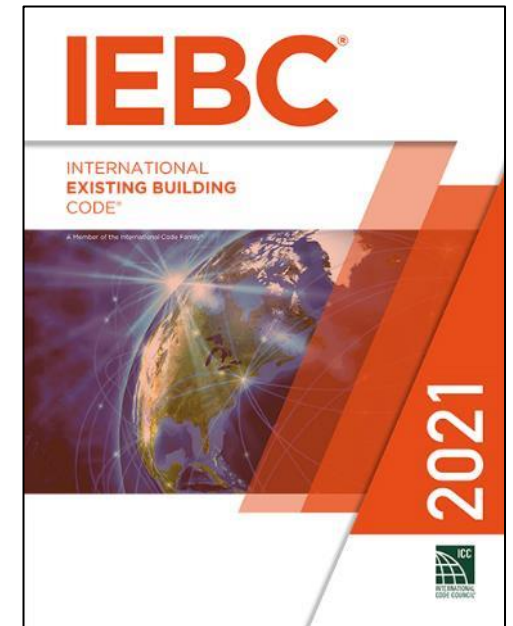
- *Performance* Compliance

- Scoring system that evaluates
  - Fire safety
  - Means of egress
  - General Safety
- Negative score in one category means non-compliance and additional upgrades needed



# Work Area Compliance

- Similar to prescriptive method
- Work area is that for which a building permit is obtained
- Maintain prior level of compliance
  - Fire protection systems
  - Means of egress
  - Accessibility

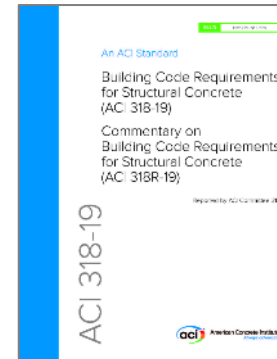
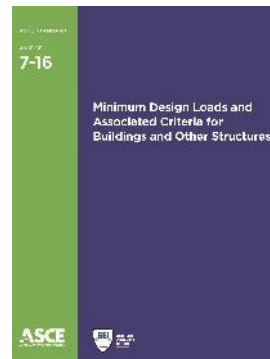


# Using the IBC

CHAPTERS	SUBJECTS
1–2	Administration and definitions
3	Use and occupancy classifications
4, 31	Special requirements for specific occupancies or elements
5–6	Height and area limitations based on the type of construction
7–9	Fire-resistance and protection requirements
10	Requirements for evacuation
11	Specific requirements to allow use and access to a building for persons with disabilities
12–13, 27–30	Building systems, such as lighting, HVAC, plumbing fixtures, elevators
14–26	Structural components—performance and stability
32	Encroachment outside of property lines
33	Safeguards during construction
34	Reserved
35	Referenced standards
Appendices A–O	Appendices

# Codes and Standards

- **“Codes”** are adopted by the legal authority in a jurisdiction
  - Establish minimum performance requirements to achieve life safety and property protection
  - Are written in “mandatory” language indicating ***what*** must be done
- **“Standards”** are referenced in the codes and indicate ***how*** to achieve what must be done



# Authority

- Local jurisdiction creates Department of Building Safety
- Building official appointed to
  - Manage the department
  - Review plans
  - Issue permits
  - Inspect work for compliance with codes and plans
  - Issue Certificates of Occupancy
  - Interpret code requirements

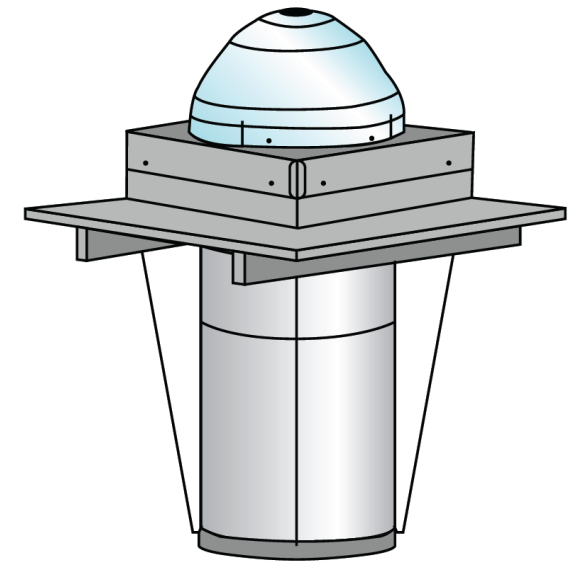
**Certificate of Occupancy**  
(Address of Structure)

This (applicable portion of structure) has been inspected for compliance with the laws and ordinances of (jurisdiction) and is hereby issued a Certificate of Occupancy

Building permit number _____	Special conditions _____
Applicable edition of code _____	_____
Occupancy classification _____	_____
Type of construction _____	_____
Design occupant load _____	Building Official _____
Sprinkler system required _____	_____
Name and address of owner or owner's authorized agent _____	

# Alternative Materials & Methods

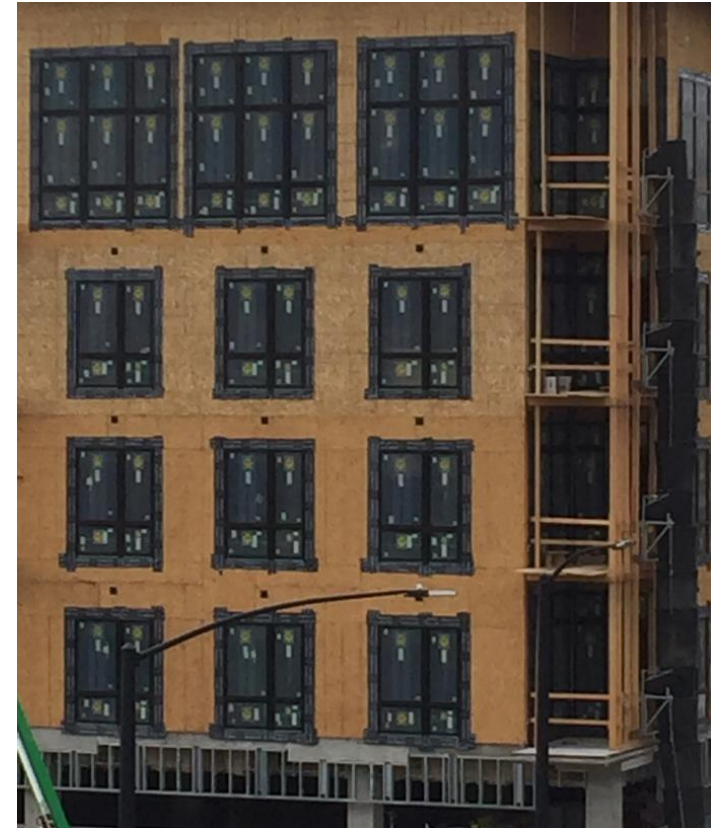
- Designers can submit a request to meet code requirements with AM&M
- Building official reviews to determine compliance with purpose and intent of code
- Alternative must be at least equivalent in quality, strength, effectiveness, fire resistance, durability and safety
- ICC Evaluation Service (ICC-ES) reviews and provides reports



# Permits

## Required for:

- New construction
- Remodeling
- Building an addition
- Change of occupancy





# Permits

- Exempt projects
  - Storage sheds less than 120 square feet
  - Fences not over 7 feet in height
  - Retaining walls not over 4 feet in height
  - Painting and wallpaper installation
  - Playground equipment accessory to 1- and 2-family dwellings
  - Other minor construction
- Permit exemption does not allow for nonconformance with code



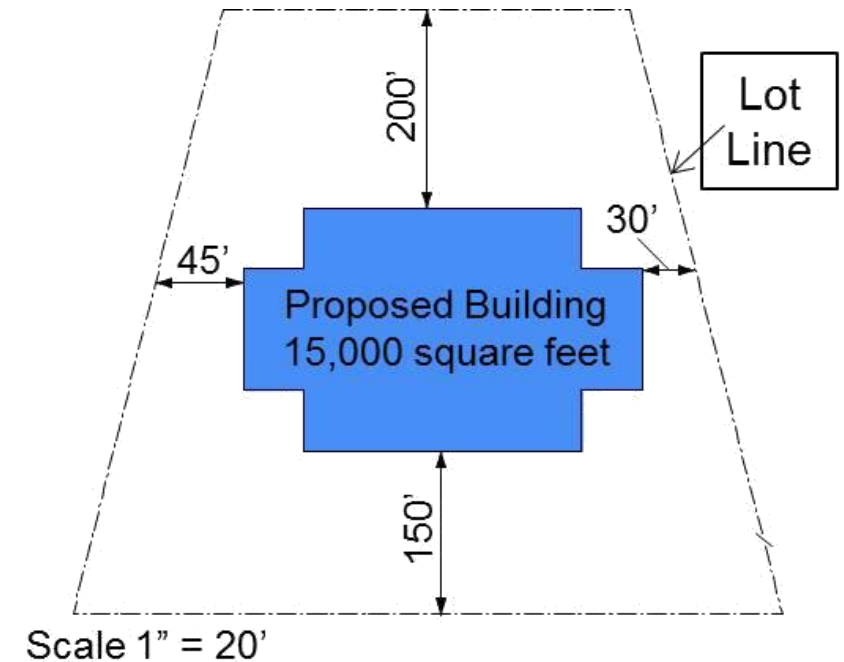
# Submittal Documents

## Drawings

- Site plan
- Floor plans
- Elevations
- Details

## Specifications

- Manufacturer installation instructions
- Minimum 2 sets submitted



# Plan Review

- Building department reviews plans for code compliance and other applicable jurisdiction laws
- If plans are compliant, a permit can be issued
- If plans have discrepancies, a plan review report is provided to the applicant
- Applicant makes corrections and resubmits plans for review
- Permit is issued when plans are approved



# Inspections

- Confirm compliance with plans and code
- Holder of permit requests inspection
- Work cannot be covered until inspection complete

Department of Building Safety  
Phone (###) 555-4567

**INSPECTION APPROVED**

<input type="checkbox"/> Building	<input type="checkbox"/> Plumbing
<input type="checkbox"/> Electrical	<input type="checkbox"/> Mechanical

Description: \_\_\_\_\_

Comments \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Date: \_\_\_\_\_

Inspector: \_\_\_\_\_

# Footing & Foundation

- Inspectors check forms and reinforcing steel to ensure correct size and proper location
- Concrete – inspection after forms are constructed and reinforcing steel installed
- Masonry – inspection for correct masonry, mortar, grout and reinforcing steel



# Concrete Slab and Under-floor

Concrete slabs can contain

- Reinforcing steel
- Conduits
- Piping
- Other equipment

Inspection typically after

- Plumbing inspector checks plumbing installation
- Electrical inspector checks underground electrical equipment





# Lowest Floor Elevation

- Where flooding is possible, buildings are to be elevated above 100-yr flood level
- Confirm lowest occupied floor elevated at or above design flood elevation





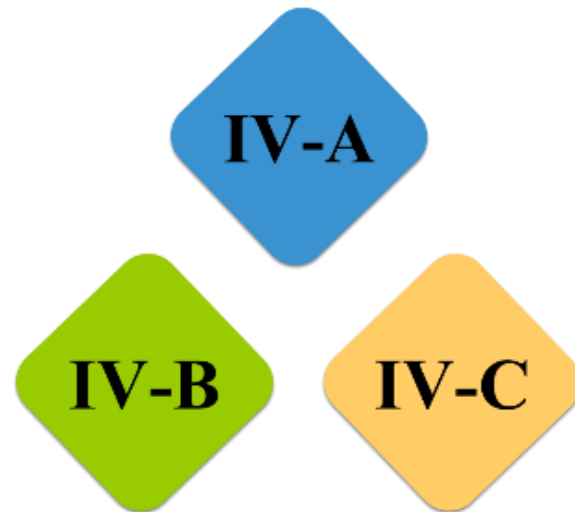
# Frame

- Structure of the building inspected
- Confirm correct size and installation of building's structural members
- Frame inspection AFTER all plumbing, mechanical and electrical systems
  - Installed
  - Inspected
  - Approved



# Connection Fire Protection

- Types IV-A, IV-B, IV-C
- Connection fire-resistance ratings by wood cover
- Inspect wood cover before other finishes installed



# Lath and Gypsum

- Many buildings use gypsum board to provide fire protection or shear resistance
- Inspector confirms that materials are installed to provide
  - Level of specified fire protection
  - Shear resistance designed



# Weather-exposed Balcony Waterproofing

- Inspection of moisture barrier required prior to membrane being concealed
- Balconies or other elevated walking surfaces exposed to water from direct blowing rain, snow or irrigation systems



# Fire- and Smoke-resistant Penetrations

Penetrations (holes) in fire-rated components

- Protected with a material that fills them when piping or wiring melts out in a fire

Confirm installation per manufacturer's instructions

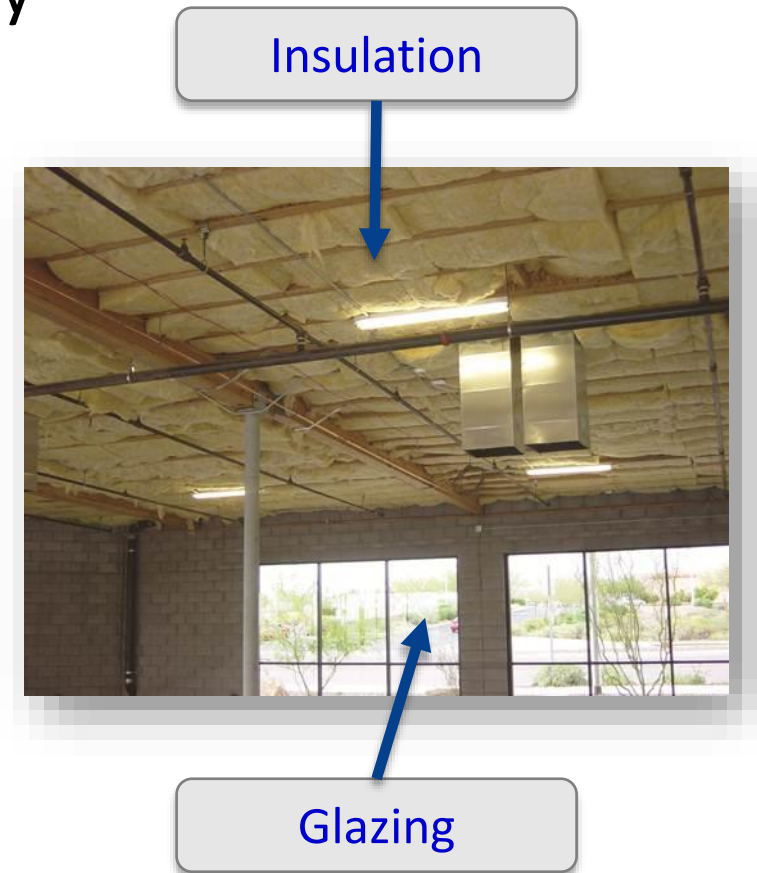




# Energy Efficiency

Energy efficiency materials installed correctly

- Insulation values
- Sealing
- Equipment installation



# Special Inspections

Certain portions of buildings may require 3<sup>rd</sup> party special inspections:

- Expertise in particular materials and designs
- Hired by building owner
- Report findings to building department

Third-party inspections required on materials such as:

- Structural concrete
- Structural steel
- Masonry
- Tall mass timber
- Helical piers
- Fire-resistant penetrations/joints





# Final

- Confirm all work covered by permit is completed according to plans and applicable code
- When final inspection approved
  - Owner receives Certificate of Occupancy
  - Allows building use



*Certificate of Occupancy*  
(Address of Structure)

This (applicable portion of structure) has been inspected for compliance with the laws and ordinances of (jurisdiction) and is hereby issued a Certificate of Occupancy

Building permit number _____	Special conditions _____
Applicable edition of code _____	_____
Occupancy classification _____	_____
Type of construction _____	_____
Design occupant load _____	Building Official _____
Sprinkler system required _____	_____
Name and address of owner or owner's authorized agent _____	

# Board of Appeals

- Building official is responsible for code interpretation
- Designer or contractor may disagree with interpretation
  - Can request a hearing with board of appeals
- Board of appeals
  - Evaluates information against code intent
  - Renders a decision regarding code interpretation



# Definitions

- IBC includes definitions for specific terms
- Undefined terms
  - Other I-Code definitions apply
  - Normal use of a term as it applies to the code
- Defined terms are *italicized* in code text

## SECTION 202 DEFINITIONS

**[BG] 24-HOUR BASIS.** The actual time that a person is an occupant within a facility for the purpose of receiving care. It shall not include a facility that is open for 24 hours and is capable of providing care to someone visiting the facility during any segment of the 24 hours.

**[BS] AAC MASONRY.** *Masonry* made of autoclaved aerated concrete (AAC) units, manufactured without internal reinforcement and bonded together using thin- or thick-bed *mortar*.

**[BE] ACCESSIBLE.** A site, *building*, *facility* or portion thereof that complies with Chapter 11.

# Poll Question

1. A building design can never stray from requirements found in the building code.
  - A. True
  - B. False



# Poll Question

2. Who is responsible to arrange for inspections of completed work?
- a. Registered design professional
  - b. General contractor
  - c. Owner
  - d. Building permit holder



# Poll Question

3. How long must work remain open for inspection after it is requested?
- a. One week
  - b. Two weeks
  - c. One month
  - d. Until work is inspected



# Discussion





# Building Planning



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# Basic Occupancies

- 10 occupancy classifications
- Subdivisions lead to 26 classifications
- Based on use and function
- Most important part of plan review process



# Occupancy Classification

- Where a space is to be occupied for different purposes at different times, all requirements applicable to each use is considered
- Buildings with two or more distinct occupancy classifications must comply with **Section 508** for **mixed-occupancy buildings**



# Group A (assembly) – civic, social or religious

A-1	...usually fixed seating, intended for production and viewing of performing arts or motion pictures
A-2	...food and/or drink consumption
A-3	...worship, recreation, or amusement and other uses not classified elsewhere in Group A
A-4	...indoor sporting events and activities with spectator seating
A-5	...participation in or viewing outdoor activities



# Group B (business)

B

...office, professional, or service-type transactions, including storage of records and accounts





# Group E (educational)

E	...6+ persons at any one time for educational purposes through 12th grade and child-care facilities
Day Care	...5+ children older than 2½ who receive educational, supervision or personal care services < 24 hrs/day



# Group F (factory)

Group F (factory) – assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing not classified H (hazard) or S (storage)

F-1	...industrial uses not classified as F-2 Low Hazard
F-2	...industrial uses involving fabrication or manufacturing of noncombustible materials which during finishing, packing, or processing do not involve a significant fire hazard





# Group H (high hazard)

Group H (high hazard) – manufacturing, processing, generation or storage of materials that constitute a physical or health hazard in quantities in excess of those allowed in control areas

H-1	...materials that pose a detonation hazard
H-2	...materials that pose a deflagration hazard or a hazard from accelerated burning
H-3	...materials that readily support combustion or that pose a physical hazard
H-4	...materials that are health hazards
H-5	Semiconductor fabrication facilities and comparable research and development areas in which hazardous production materials (HPM) are used



# Group I (institutional)

- Group I (institutional) – care/supervision for persons who
  - May not be capable of self-preservation without physical assistance
  - Are detained for penal/correctional purposes or liberty is restricted

I-1	...16+ persons, excluding staff, who reside on a 24-hr basis in a supervised environment and receive custodial care
I-2	...medical care on a 24-hr basis for 5+ persons who are incapable of self-preservation
I-3	...5+ persons who are under restraint or security...generally incapable of self-preservation due to security measures not under occupants' control
I-4	...persons of any age who receive custodial care for less than 24 hrs by individuals other than...relatives...in a place other than the home of the person cared for



# Group M (mercantile)

M

...display and sale of merchandise which involves stocks of goods, wares or merchandise incidental to such purposes and publicly accessible



# Occupancy Classifications

Group R (residential) – for sleeping purposes when NOT

- Classified as Institutional Group I
- Regulated by IRC

R-1	...sleeping units with primarily transient occupants
R-2	...sleeping units or 2+ dwelling units with primarily permanent occupants
R-3	...primarily permanent occupants not classified as Group R-1, R-2, R-4, or I
R-4	...5 to 16 persons, excluding staff, who reside on a 24-hr basis in a supervised residential environment and receive custodial care





# Group S (storage) – not classified as hazardous

S-1	...uses that are not classified as Group S-2
S-2	...noncombustible materials such as products on wood pallets or in paper cartons with or without single thickness divisions; or in paper wrappings. Such products are permitted to have a negligible amount of plastic trim, such as knobs, handles, or film wrapping.



# Occupancy Classifications

## Group U (utility)

U

...accessory and miscellaneous structures not classified in any specific occupancy shall conform to IBC commensurate with fire and life hazard incidental to their occupancy



# Types of Construction

## Buildings' fire resistance based on

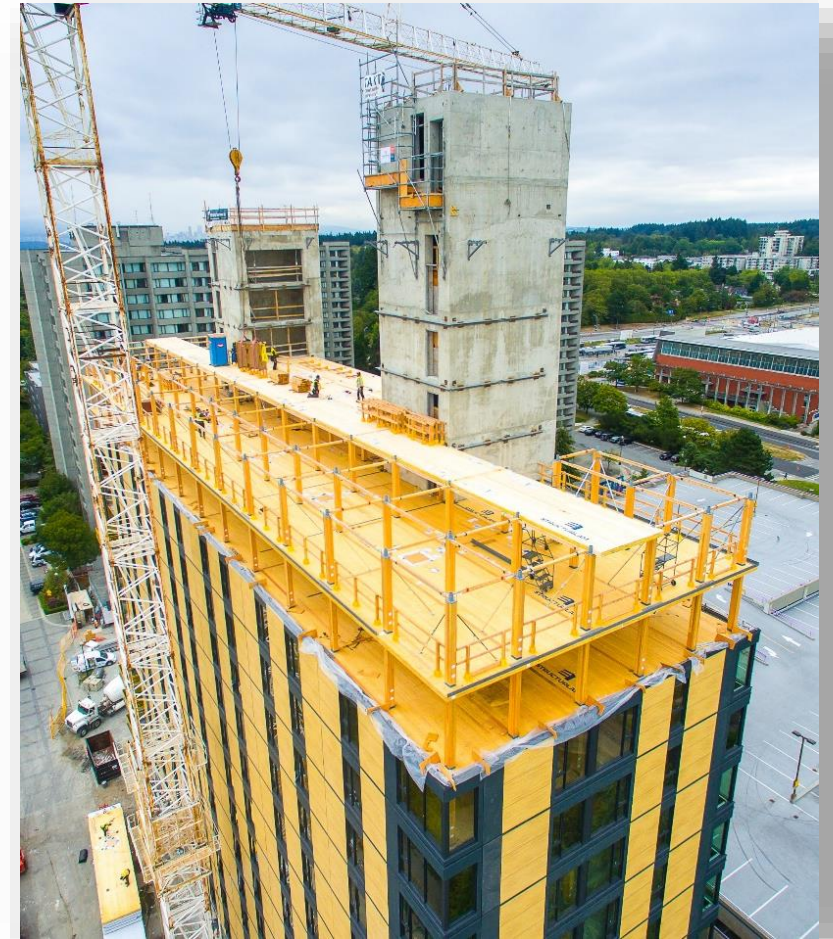
- Key building elements
  - Combustible or noncombustible
  - Protected by recognized level of fire resistance
- Permitted building size directly related to construction type





# Types of Construction (Continued)

- Buildings must be classified as single construction type
- Based on full compliance with minimum requirements for intended construction type
  - Unlike mixed-occupancy conditions where multiple uses occur



# Fire-Resistance Rating Requirements for Building Elements (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame <sup>f</sup> (see Section 202)	3 <sup>a, b</sup>	2 <sup>a, b, c</sup>	1 <sup>b, c</sup>	0 <sup>c</sup>	1 <sup>b, c</sup>	0	3 <sup>a</sup>	2 <sup>a</sup>	2 <sup>a</sup>	HT	1 <sup>b, c</sup>	0
Bearing walls												
Exterior <sup>e, f</sup>	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3 <sup>a</sup>	2 <sup>a</sup>	1	0	1	0	3	2	2	1/HT <sup>g</sup>	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior <sup>d</sup>	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 1/2 <sup>b</sup>	1 <sup>b, c</sup>	1 <sup>b, c</sup>	0 <sup>c</sup>	1 <sup>b, c</sup>	0	1 1/2 <sup>b</sup>	1	1	HT	1 <sup>b, c</sup>	0

*Refer to Code Book*

# Comparison of Construction Types

<b>Type I-A—Fire-resistance-rated, noncombustible required</b>			
Exterior Bearing Walls 3 Hrs.	Structural Frame 3 Hrs.	Floors 2 Hrs.	Roofs 1½ Hrs.
<b>Type I-B—Fire-resistance-rated, noncombustible required</b>			
Exterior Bearing Walls 2 Hrs.	Structural Frame 2 Hrs.	Floors 2 Hrs.	Roofs 1 Hr.
<b>Type II-A—Fire-resistance-rated, noncombustible required</b>			
Exterior Bearing Walls 1 Hr.	Structural Frame 1 Hr.	Floors 1 Hr.	Roofs 1 Hr.
<b>Type II-B—Nonrated, noncombustible required</b>			
Noncombustible materials, but no fire resistance required			
<b>Type III-A—Fire-resistance-rated, combustible permitted, with fire-resistance-rated, noncombustible or FRTW exterior walls</b>			
Exterior Bearing Walls 2 Hrs.	Structural Frame 1 Hr.	Floors 1 Hr.	Roofs 1 Hr.
<b>Type III-B—Nonrated, combustible permitted, with fire-resistance-rated, noncombustible or FRTW exterior walls</b>			
Exterior Bearing Walls 2 Hrs.	Structural Frame None	Floors None	Roofs None

# Comparison of Construction Types (Continued)

<b>Type IV-A—Fire-resistance-rated, protected mass timber</b>			
Exterior Bearing Walls 3 Hrs.	Structural Frame 3 Hrs.	Floors 2 Hrs.	Roofs 1½ Hrs.
<b>Type IV-B—Fire-resistance-rated, protected mass timber with limited unprotected elements</b>			
Exterior Bearing Walls 2 Hrs.	Structural Frame 2 Hrs.	Floors 2 Hrs.	Roofs 1 Hr.
<b>Type IV-C—Fire-resistance-rated, exposed mass timber with limited protected elements</b>			
Exterior Bearing Walls 2 Hrs.	Structural Frame 2 Hrs.	Floors 2 Hrs.	Roofs 1 Hr.
<b>Type IV-HT—Heavy Timber</b>			
Exterior Bearing Walls 2 Hrs.	Structural Frame Heavy Timber or 1 Hr.	Floors Heavy Timber	Roofs Heavy Timber
<b>Type V-A—Fire-resistance-rated, combustible permitted</b>			
Exterior Bearing Walls 1 Hr.	Structural Frame 1 Hr.	Floors 1 Hr.	Roofs 1 Hr.
<b>Type V-B—Nonrated, combustible permitted</b>			
Combustible materials permitted, but no fire resistance required			

# Automatic Fire Sprinkler Systems

- NFPA 13
  - Sprinklers required in all rooms of a building
  - Also provided in concealed spaces
- NFPA 13R
  - Limited to residential uses  $\leq 4$  stories and  $\leq 60$  feet
  - Sprinklers can be omitted from concealed combustible spaces and small closets and restrooms
- NFPA 13D
  - Limited to 1- and 2-family dwellings



# Allowable Height (feet)

OCCUPANCY CLASSIFICATION	TYPE OF CONSTRUCTION												
	See Footnotes	Type I		Type II		Type III		Type IV				Type V	
		A	B	A	B	A	B	A	B	C	HT	A	B
A, B, E, F, M, S, U	NS	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	86	75	270	180	85	85	70	60
R	NS	UL	160	65	55	65	55	65	65	65	65	50	40
	S13D	60	60	60	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	270	180	85	85	70	60

[Ref. Table 504.3]



# Building Height

Determine Average Grade Plane

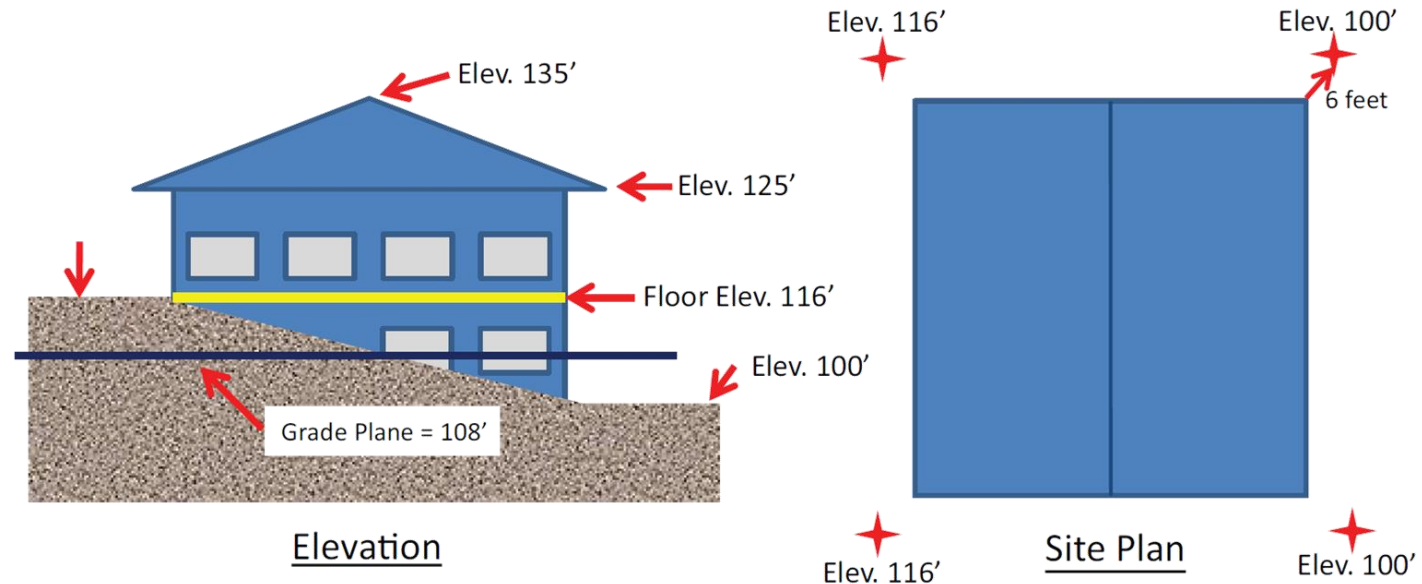
$$\begin{array}{rcllcl} 100 & + & 100 & + & 116 & + & 116 & = & 432 \\ 432 & \div & 4 & = & \mathbf{108'} \end{array}$$

Determine Average Roof Height

$$\begin{array}{rclcl} 125 & + & 135 & = & 260 \\ 260 & \div & 2 & = & 130 \end{array}$$

Determine Building Height

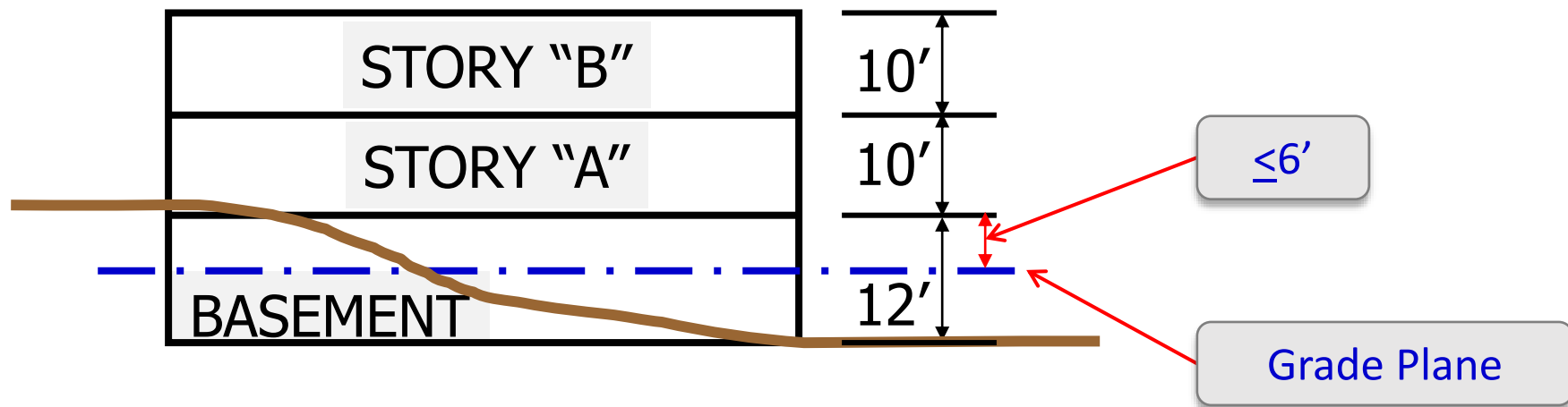
$$130 - 108 = \mathbf{22'}$$





# Stories Above Grade Plane

- Determine Grade Plane
- Determine if bottom story is basement



The bottom story is a basement because the floor of Story "A" is  $\leq 6'$  above grade plane

# Allowable Number of Stories

OCCUPANCY CLASSIFICATION	TYPE OF CONSTRUCTION												
	See Footnotes	Type I		Type II		Type III		Type IV				Type V	
		A	B	A	B	A	B	A	B	C	HT	A	B
A-2	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
B	NS	UL	11	5	3	5	3	5	5	5	5	3	2
	S	UL	12	6	4	6	4	18	12	9	6	4	3
M	NS	UL	11	4	2	4	2	4	4	4	4	3	1
	S	UL	12	5	3	5	3	12	8	6	5	4	2
R-2	NS	UL	11	4	4	4	4	4	4	4	4	3	2
	S13R	4	4									4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3

[Ref. Table 504.4]

# Height and Area Limitations

- Occupied roof occupancy based on Table 504.4 for story immediately below
- Roof area not added to building area regulated by §506



# Height and Area Limitations

A-2 occupancy on roof

A-2 8,000 square feet	R-1 38,000 square feet	
R-1 46,000 square feet		
R-1 46,000 square feet		
A-3 24,000 square feet	R-1 8,000 square feet	M 14,000 square feet

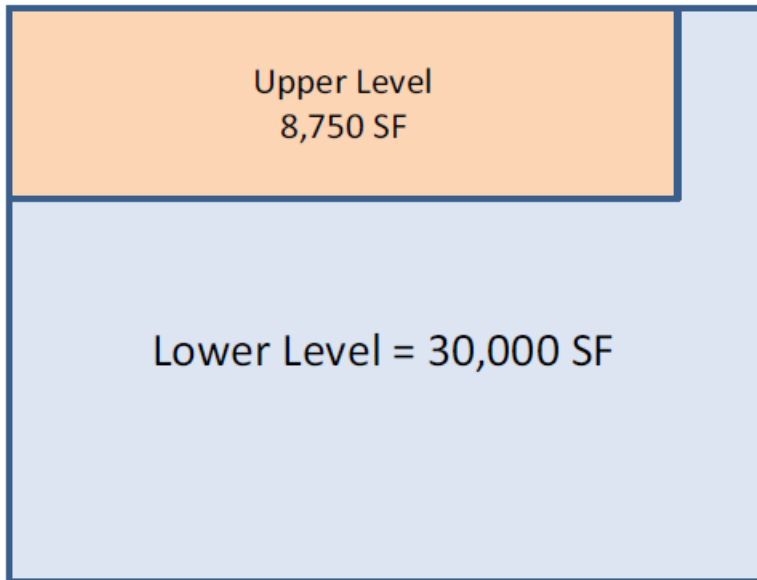
A-2 must be multiplied by Table 1 on the order to get on the

**A-2 must be allowed  
by Table 504.4 to be  
on the 4<sup>th</sup> floor in  
order to be allowed  
on the roof**

# Mezzanines

Do not count as a story when evaluating building area or number of stories

- $\leq 1/3$  floor area below
- $\leq 2/3$  area for special industrial Type I or II
- $\leq 1/2$  area in Type I and II
  - Sprinklered
  - EV/AC system



If area below upper level is not enclosed  
 $8,750/30,000 = 0.29$   
upper level considered mezzanine

If area below upper level is enclosed  
 $8,750/21,250 = 0.41$   
upper level considered second story

# Allowable Building Area Factor (SF)

OCCUPANCY CLASSIFICATION	TYPE OF CONSTRUCTION												
	See Foot notes	Type I		Type II		Type III		Type IV				Type V	
		A	B	A	B	A	B	A	B	C	HT	A	B
A-2	NS	UL	UL	15500	9500	14000	9500	45000	30000	18750	15000	11500	6000
	S1	UL	UL	62000	38000	56000	38000	180000	120000	75000	60000	46000	24000
	SM	UL	UL	46500	28500	42000	28500	135000	90000	56250	45000	34500	18000
B	NS	UL	UL	37500	23000	28500	19000	108000	72000	45000	36000	18000	9000
	S1	UL	UL	150000	92000	114000	76000	432000	288000	180000	144000	72000	36000
	SM	UL	UL	112500	69000	85500	57000	324000	216000	135000	108000	54000	27000
M	NS	UL	UL	21500	12500	18500	12500	61500	41000	26625	20500	14000	9000
	S1	UL	UL	86000	50000	74000	50000	246000	164000	102500	82000	56000	36000
	SM	UL	UL	64500	37500	55500	37500	184500	123000	76875	61500	42000	27000
R-2	NS	UL	UL	24000	16000	24000	16000	61500	41000	25625	20500	12000	7000
	S13R												
	S1	UL	UL	96000	64000	96000	64000	246000	164000	102500	82000	48000	28000
	SM	UL	UL	72000	48000	72000	48000	184500	123000	76875	61500	36000	21000

[Ref. Table 506.2]

# Allowable Area Determination

$$A_a = A_t + (NS \times I_f) \quad (\text{Eq 5-1})$$

where:

$A_a$  = Allowable building area per story (ft<sup>2</sup>)

$A_t$  = Allowable area factor per Table 506.2

$NS$  = Allowable area factor per Table 506.2 for  
nonsprinklered building

$I_f$  = Area increase factor due to frontage per §506.3

*Refer to Code Book*





# Area Increase for Frontage ( $I_f$ )

- $\geq 25\%$  of perimeter on public way or open space

PERCENTAGE OF BUILDING PERIMETER	OPEN SPACE (ft)			
	0 to less than 20	20 to less than 25	25 to less than 30	30 or greater
0 to less than 25	0	0	0	0
25 to less than 50	0	0.17	0.21	0.25
50 to less than 75	0	0.33	0.42	0.50
75 to 100	0	0.50	0.63	0.75

[Ref. Table 506.3.3]

# Area Increase for Frontage ( $I_f$ )

Interpolation permitted

- Lowest value in “Open Space” range
- Highest value in “% Building Perimeter” range

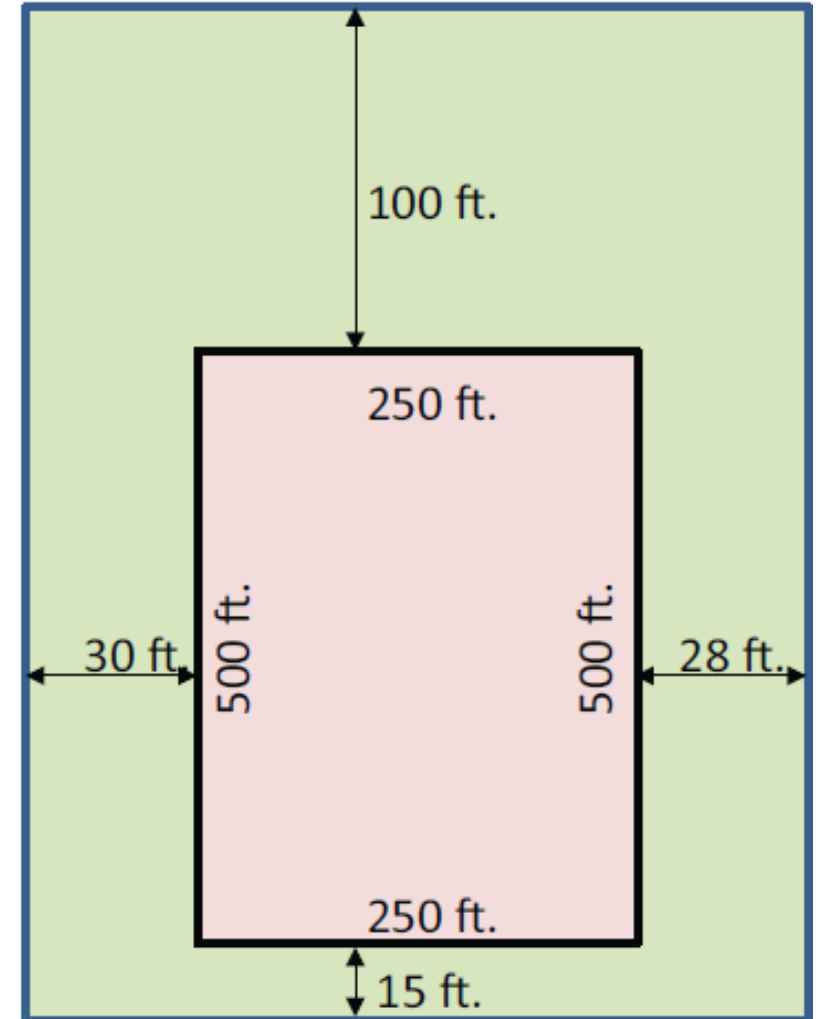
PERCENTAGE OF BUILDING PERIMETER	OPEN SPACE (ft)			
	0 to less than 20	20 to less than 25	25 to less than 30	30 or greater
0 to less than 25	0	0	0	0
25 to less than 50	0	0.17	0.21	0.25
50 to less than 75	0	0.33	0.42	0.50
75 to 100	0	0.50	0.63	0.75

[Ref. Table 506.3.3]

OR use  $I_f = [F/P - 0.25] W/30$   
based on 2018 IBC Eq. 5-5

# Minimum Frontage Distance (W)

- Right angle to building
- $W \geq 20$  feet
  - Closest lot line
  - Width of public way
  - Exterior of adjacent building

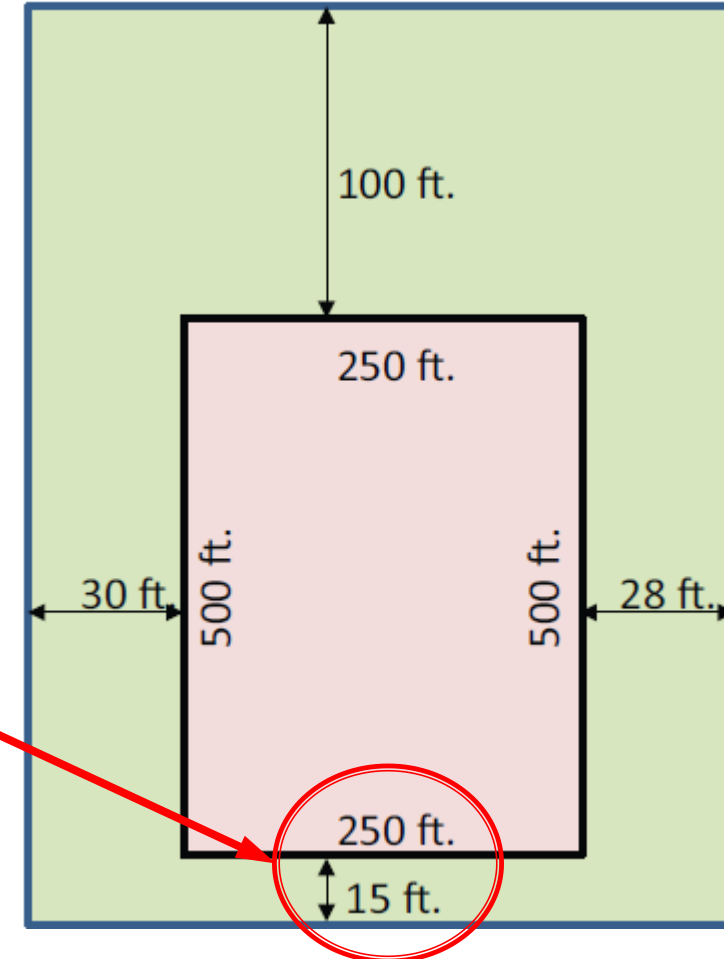


# Area Increase for Frontage

Building perimeter = 1500'

- $W \geq 20$  feet
  - 500
  - 500
  - 250
- $W < 20$  feet
  - 250

$$1250/1500 = \mathbf{83\%}$$



# Area Increase for Frontage ( $I_f$ )

- 83% of building perimeter with  $\geq 30'$  open space

PERCENTAGE OF BUILDING PERIMETER	OPEN SPACE (ft)			
	0 to less than 20	20 to less than 25	25 to less than 30	30 or greater
0 to less than 25	0	0	0	0
25 to less than 50	0	0.17	0.21	0.25
50 to less than 75	0	0.33	0.42	0.50
75 to 100	0	0.50	0.63	0.75

[Ref. Table 506.3.3]

$$I_f = 0.75$$

# Allowable Area for Frontage

Given

- Type IIA Business occupancy
- With sprinklers
- Single story with single occupancy
  - $A_t = S1 = 150,000$

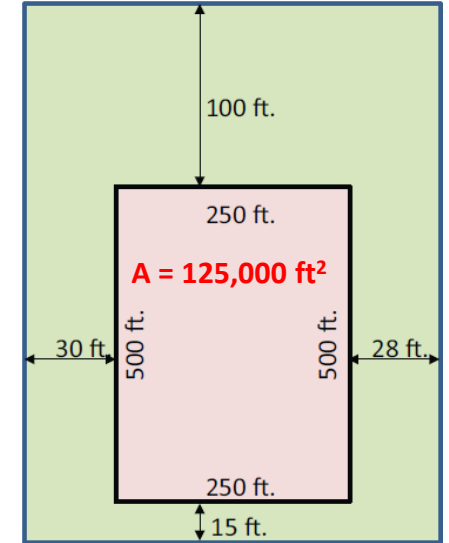
$$A_a = A_t + (NS \times I_f)$$

$$A_a = 150,000 + (37,500 \times 0.75)$$

$$A_a = 150,000 + 28,125$$

$$A_a = 178,125 > 125,000 \quad \text{OK}$$

OCCUPANCY CLASSI- FICATION	See Foot notes	Type I		Type II	
		A	B	A	B
A-2	NS	UL	UL	15500	9500
	S1	UL	UL	62000	38000
	SM	UL	UL	46500	28500
B	NS	UL	UL	37500	23000
	S1	UL	UL	150000	92000
	SM	UL	UL	112500	69000



# Single Occupancy – Multi-story

$$A_a = [A_t + (NS \times I_f)] \times S_a \quad (\text{Eq 5-2})$$

where terms defined earlier except:

$S_a$  = Actual number of stories above grade plane  $\leq 3$

For buildings with NFPA 13R sprinkler system,  $S_a \leq 4$

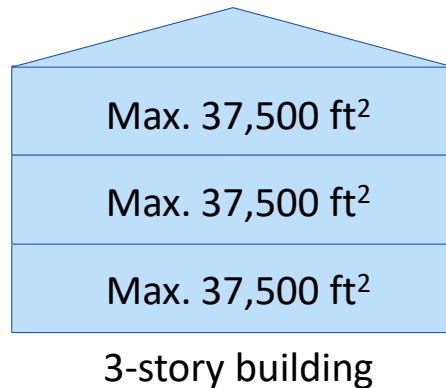
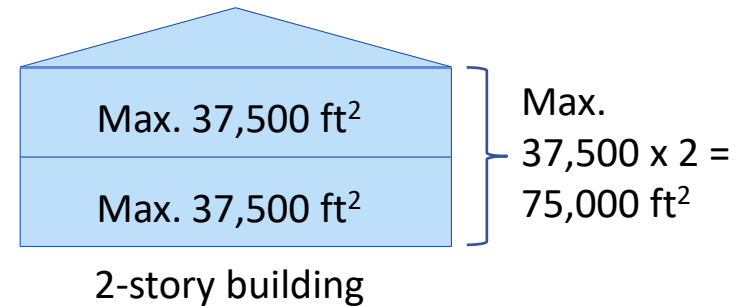
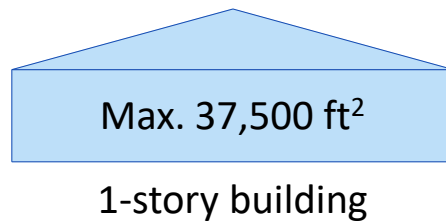
*Refer to Code Book*



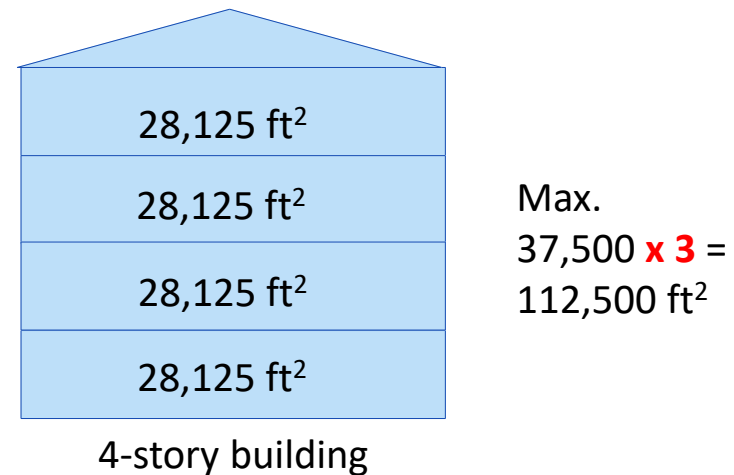


# Floor Area in Multi-story Building

Type IIA Group B Office – Nonsprinklered  
Table 506.2: NS = 37,500 ft<sup>2</sup>



Max.  
37,500 x 3 =  
112,500 ft<sup>2</sup>



# Interior Dimensions

- Habitable rooms
  - Room width  $\geq 7'$ 
    - Exception for kitchens with  $\geq 3'$  clear passageway
  - Ceiling height  $\geq 7'-6''$
  - Barrier required to protect occupants from objects protruding into clear height
- Egress path
  - Ceiling height  $\geq 7'-6''$
  - Door height  $\geq 80''$
  - Door width  $\geq 32''$



# Mixed-use and Occupancy

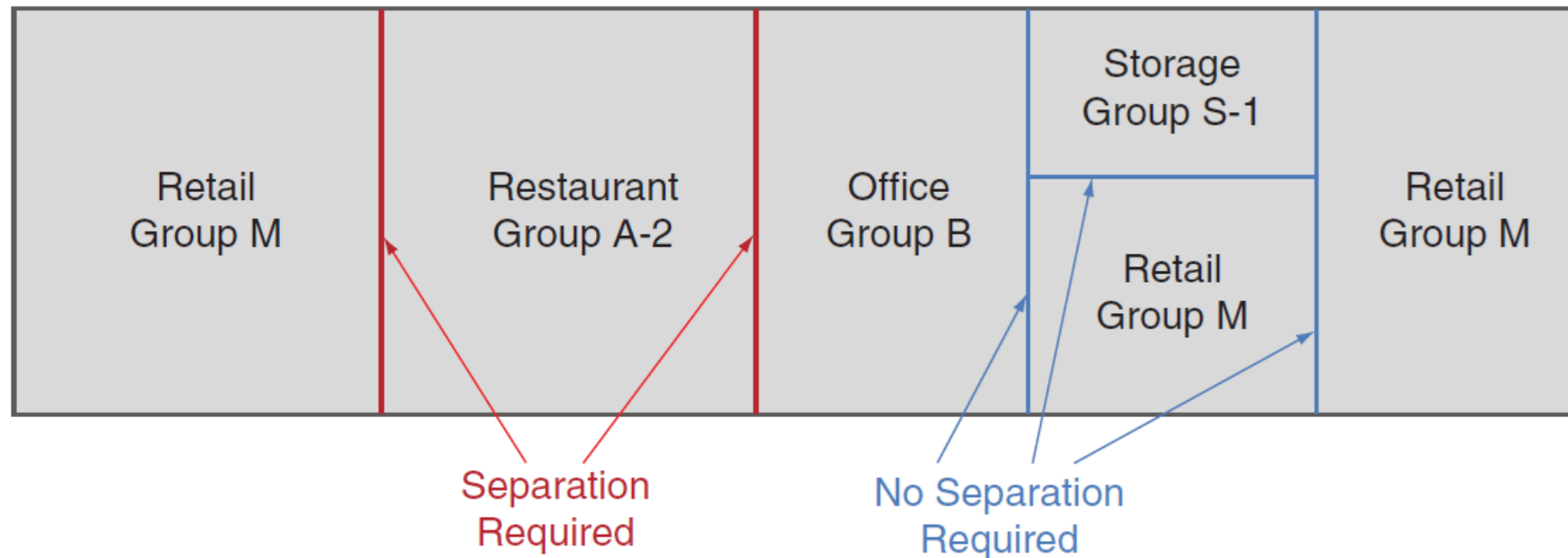
**TABLE 508.4** Required Separation of Occupancies (Hours)

Occupancy	A, E		I-1, I-3, I-4		I-2		R		F-2, S-2, U		B, F-1, M, S-1		H-1		H-2		H-3, H-4		H-5	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2	NP	NP	3	4	2	3	2	NP
I-1, I-3, I-4	1	2	N	N	2	NP	1	NP	1	2	1	2	NP	NP	3	NP	2	NP	2	NP
I-2	2	NP	2	NP	N	N	2	NP	2	NP	2	NP	NP	NP	3	NP	2	NP	2	NP
R	1	2	1	NP	2	NP	N	N	1	2	1	2	NP	NP	3	NP	2	NP	2	NP
F-2, S-2, U	N	1	1	2	2	NP	1	2	N	N	1	2	NP	NP	3	4	2	3	2	NP
B, F-1, M, S-1	1	2	1	2	2	NP	1	2	1	2	N	N	NP	NP	2	3	1	2	1	NP
H-1	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	N	NP	NP	NP	NP	NP	NP	NP
H-2	3	4	3	NP	3	NP	3	NP	3	4	2	3	NP	NP	N	NP	1	NP	1	NP
H-3, H-4	2	3	2	NP	2	NP	2	NP	2	3	1	2	NP	NP	1	NP	1	NP	1	NP
H-5	2	NP	2	NP	2	NP	2	NP	2	NP	1	NP	NP	NP	1	NP	1	NP	N	NP

Footnotes not shown

# Mixed Use – Separated Occupancies

- Designer's option
- Separation based on Table 508.4
- Ratio calculation to determine allowable area



# Mixed Use – Separated Occupancies

Retail Group M 1,500 SF	Restaurant Group A-2 1,500 SF	Office Group B 1,250 SF	Storage Group S-1 500 SF	Retail Group M 1,250 SF
			Retail Group M 1,000 SF	

## Given:

Mixed occupancy building shown  
One Story

Type VB Construction

No Fire Sprinklers

No Frontage Increase

Allowable Areas

Group A-2 = 6,000 SF

Group B = 9,000 SF

Group M = 9,000 SF

Group S-1 = 9,000 SF

## Evaluate Allowable Area:

Ratio Calculations

Group A-2  $1,500/6,000 = 0.25$

Group B  $1,250/9,000 = 0.14$

Group M  $3,750/9,000 = 0.42$

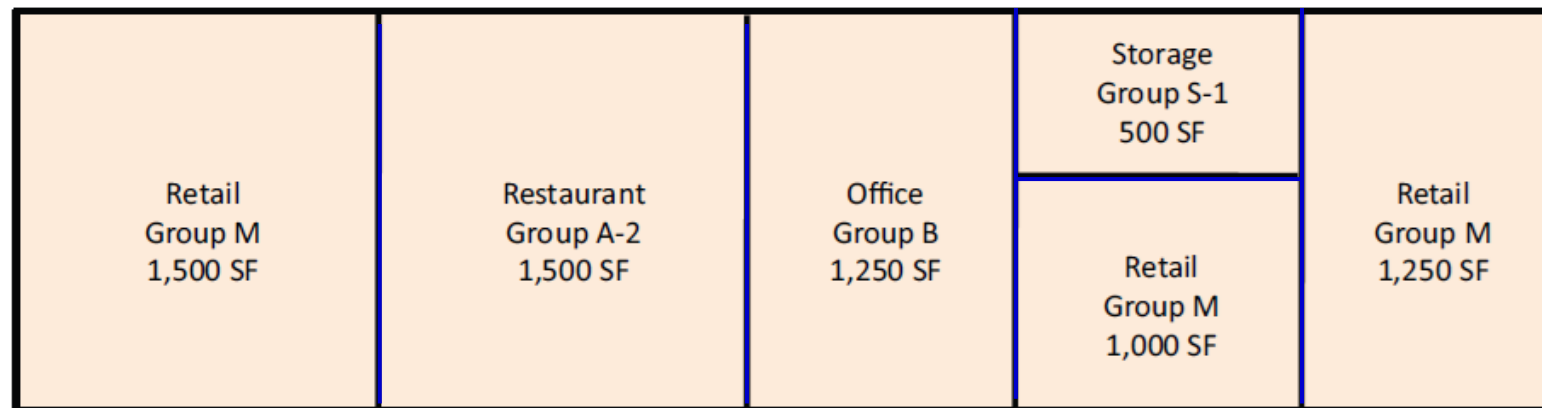
Group S-1  $500/9,000 = 0.06$

Total Ratio =  $0.87 < 1.0$  **OK**

# Mixed Use – Nonseparated Occupancies

Most restrictive requirement of each occupancy applied to entire building

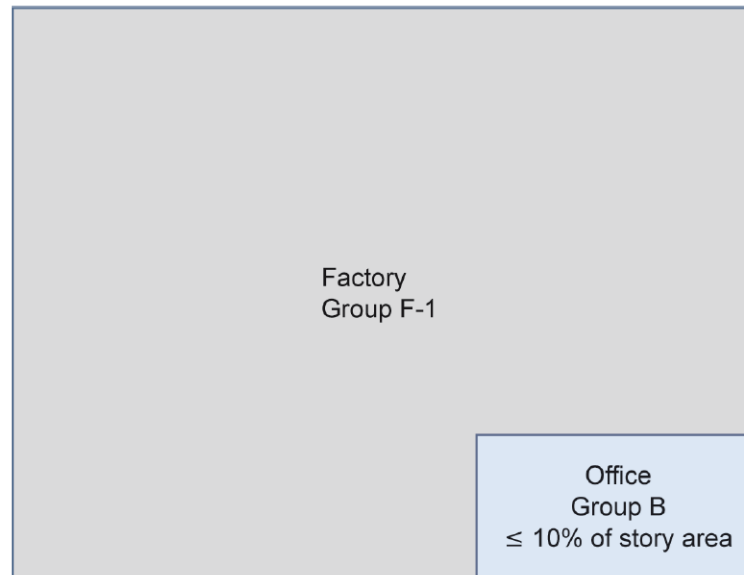
- Height
- Area
- Chapter 9 requirements



No Separation Required Between Any Occupancies

# Mixed Use – Accessory Occupancies

- **Subsidiary** occupancy to main use of building
- **Aggregate area** accessory occupancy  $\leq 10\%$  of floor area/story
- Not exceed **nonsprinklered tabular area** for accessory occupancy
- **Allowable height & stories** cannot exceed Table 504
- Accessory occupancy **individually classified**





# Live/Work Units

- Classified as R-2
- Floor area  $\leq 3,000$  square feet
- Non-residential portion  $\leq 50$  percent of floor area
- Commercial portion on 1st floor
- $\leq 5$  workers or employees



# Mixed Use – Incidental Uses

- Ancillary functions
- Higher hazards
- Protection per Table 509.1
  - Fire-rated construction, or
  - Fire sprinklers
    - Room constructed to resist smoke passage

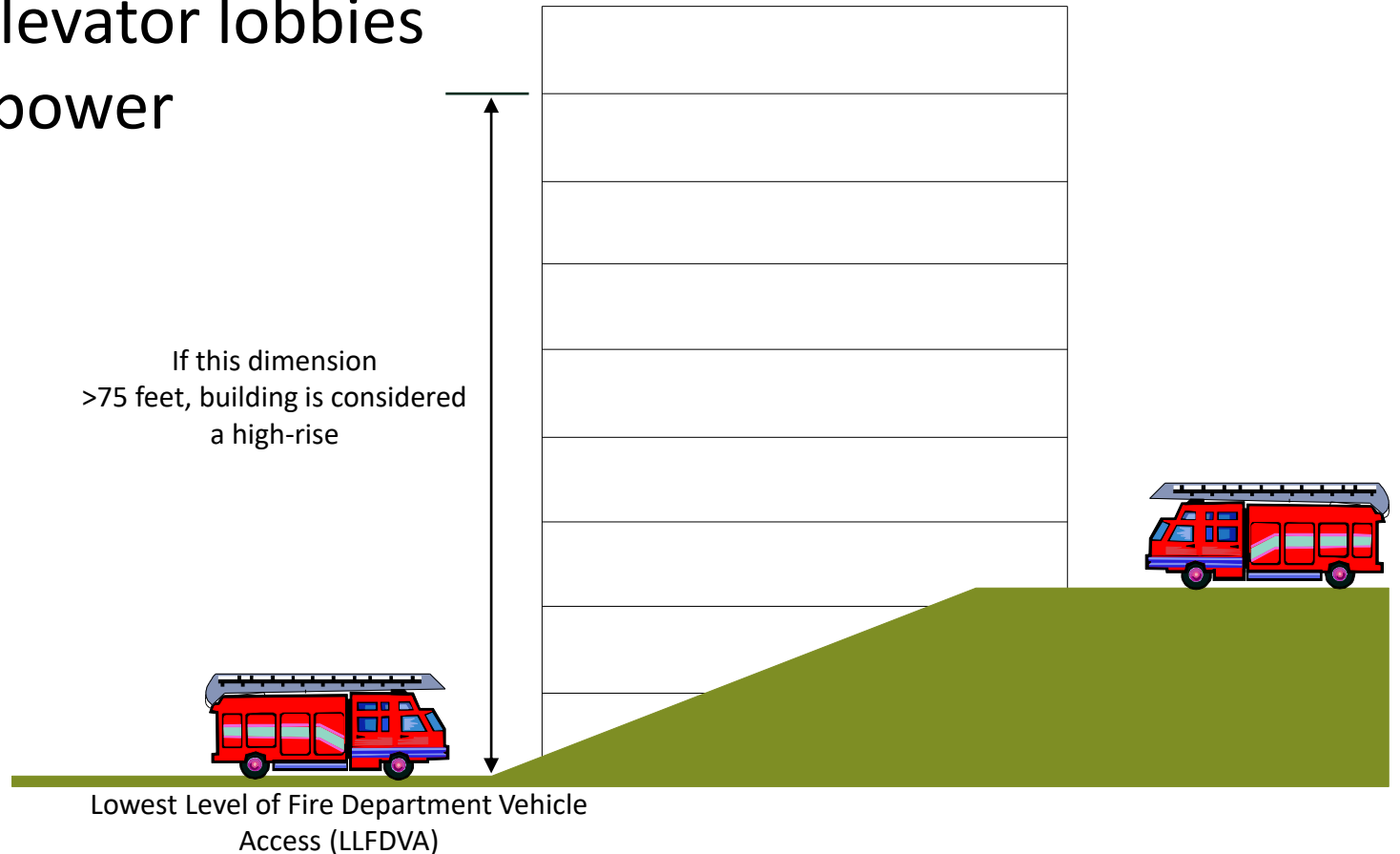


# Mixed Use – Incidental Uses

Room or Area	Separation (hours) and/or Sprinkler Protection (S)
Furnace >400,000 Btu/hour input	1 or S
Boilers >15 psi and 10 HP	1 or S
Refrigerant machinery room	1 or S
Incinerator rooms	2 and S
Paint shops	2 or (1 and S)
Group E laboratories and vocational shops	1 or S
Group I-2 laboratories	1 or S
Group I-2 laundry rooms over 100 SF	1
Group I-3 cells and Group I-2 patient rooms with padded surfaces	1
Group I-2 physical plant maintenance shops	1

# High-rise Buildings

- Smokeproof enclosure for stairways
- Smoke detection in elevator lobbies
- Standby/emergency power
- Fire alarm
- Sprinklers
- Standpipes



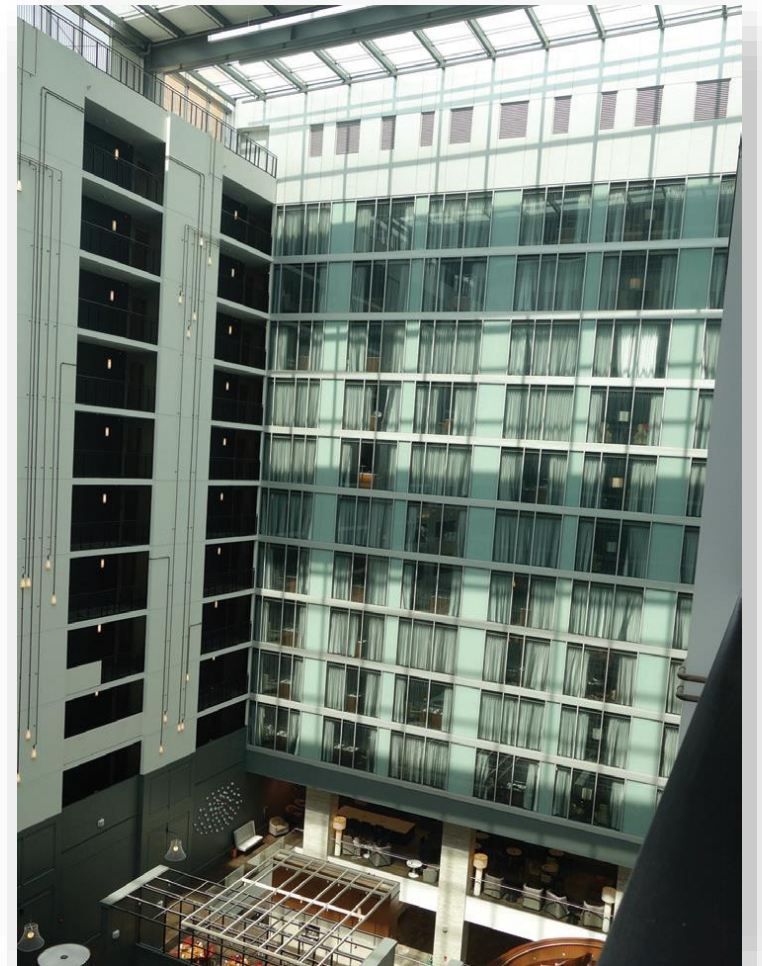
# High-rise Buildings

- Additional stairway required in high-rise > 420'
  - Other than Group R-2
- Fire service access elevator when floor level >120' above LLFDVA
- Smoke removal
  - Operable windows, OR
  - Mechanical system
- Egress path marking



# Atriums

- Fire sprinklers required throughout building
- Smoke-control system to provide safe path of egress
- Areas adjacent to atrium protected with minimum 1-hr fire-resistance-rated walls





# Garages

- Private garages
- Parking garages
  - Enclosed
    - Mechanical ventilation
    - Fire sprinklers required
  - Open
    - Natural ventilation
    - Type I, II or IV construction



*Image courtesy of SRG Partnership*

Group U  
 $\leq 1,000 \text{ ft}^2$   
Serving residential units

Group S-2  
Serving public or private  
parking use



# Repair Garages

- Definition
    - A building, structure, or portion thereof used for servicing or repairing motor vehicles
  - Solvents
  - Vehicle fluids
  - Vehicle fuel
- } Must stay below exempt amounts or classified Group H
- Gasoline, diesel
  - Liquified natural gas
  - Hydrogen, electric
- Mechanical ventilation



# Hazardous Materials

- Maximum Allowable Quantity (MAQ) per Control Area of Hazardous Materials Posing a Physical Hazard

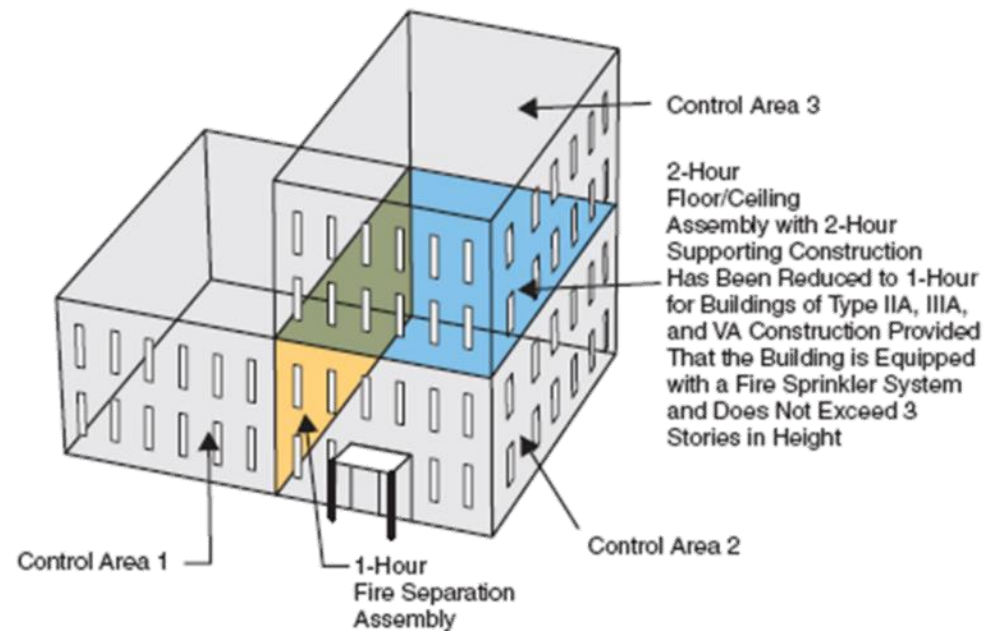
Material	Class	Cubic feet	Storage	
			Liquid gallons (pounds)	Gas (cubic feet @ NTP)
Combustible liquid	II	N/A	120	N/A
	IIIA		330	
	IIIB		13,200	
Combustible fiber	Loose	100	N/A	N/A
	Baled	1,000		
Flammable gas	Gaseous	N/A	N/A	1,000
	Liquefied		(150)	N/A

# Hazardous Materials – Footnotes

- b – Aggregate quantity shall not exceed storage
- d – Increase 100% for automatic sprinkler system
- e – Increase 100% if stored in approved storage cabinets, day boxes, gas cabinets, gas rooms or exhausted
- f – Not limited in automatic sprinkler buildings
- g – Allowed only in buildings equipped throughout with an automatic sprinkler system

# Hazardous Materials – Control Areas

- Control Areas are NOT considered an H occupancy
- Up to MAQ in each control area
- Number of control areas limited



# Hazardous Materials – Control Areas

STORY		PERCENTAGE OF THE MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA <sup>a</sup>	NUMBER OF CONTROL AREAS PER FLOOR	FIRE-RESISTANCE RATING FOR FIRE BARRIERS IN HOURS <sup>b</sup>
Above grade plane	Higher than 9	5	1	2
	7–9	5	2	2
	6	12.5	2	2
	5	12.5	2	2
	4	12.5	2	2
	3	50	2	1
	2	75	3	1
	1	100	4	1
Below grade plane	1	75	3	1
	2	50	2	1
	Lower than 2	Not Allowed	Not Allowed	Not Allowed

# Hazardous Materials

- Given: One-story building used for storage of acetic acid, (Class II combustible liquid)
- Sprinklered building with one exhausted control area
- Determine MAQ

Material	Class	Cubic feet	Storage	
			Liquid gallons (pounds)	Gas (cubic feet @ NTP)
Combustible liquid	II	N/A	120	N/A
	IIIA		330	
	IIIB		13,200	

Tabular MAQ = 120  
Footnote d = 100% increase  
 $120 \times 2 = 240$  gallons/control area  
Footnote e = 100% increase  
 $240 \times 2 = 480$  gallons/control area

# Healthcare Occupancies

Classified as Group I occupancies

- Code official needs to know
  - Amount of time people are receiving care
  - Level of care people are receiving
  - Are people capable of responding to emergency situations on their own





# Healthcare Occupancies

- Group I-1: >16 persons living 24/7
  - Assisted living facilities, halfway houses, alcohol and drug centers, group homes and congregate care facilities



# Healthcare Occupancies

- Group I-2: medical care 24/7 for >5 people
  - Condition 1 – nursing and medical care
  - Condition 2 – emergency care, surgery, obstetrics or in-patient stabilization units for psychiatric or detoxification



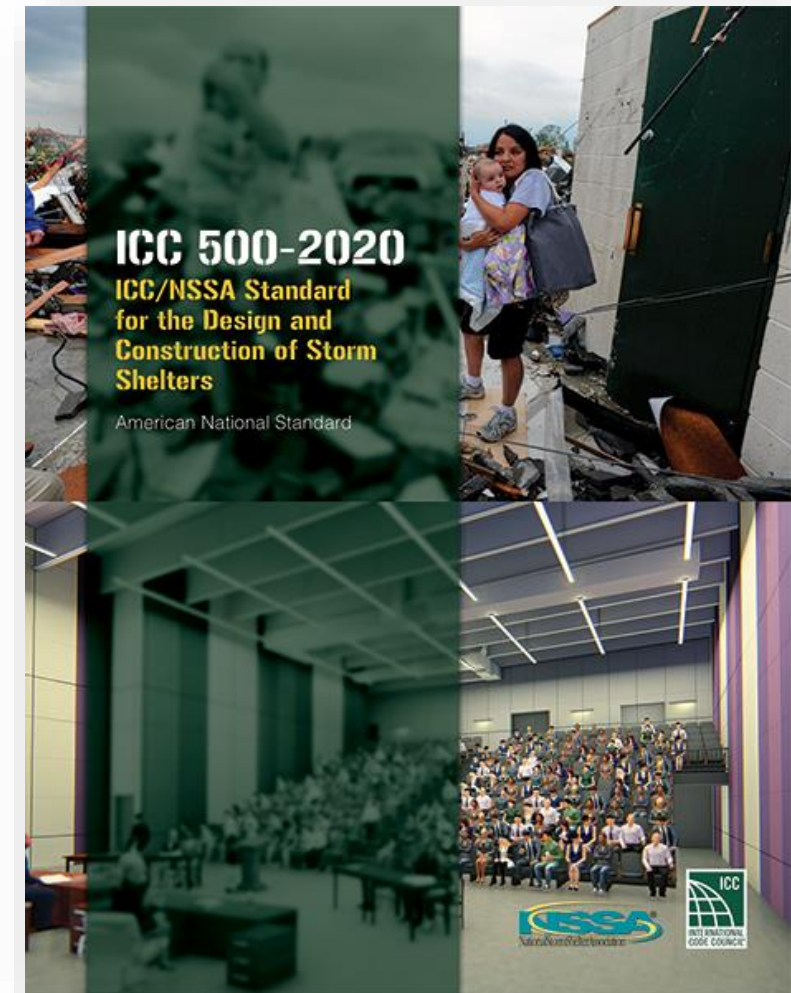
# Ambulatory Health Care Facilities

- Medical, surgical, psychiatric, nursing or similar care <24-hour basis
- $\geq 4$  individuals not capable of self-preservation
- Classified as Group B
- Fire sprinklers required
- Smoke compartments
  - When one story  $>10,000$  ft<sup>2</sup>



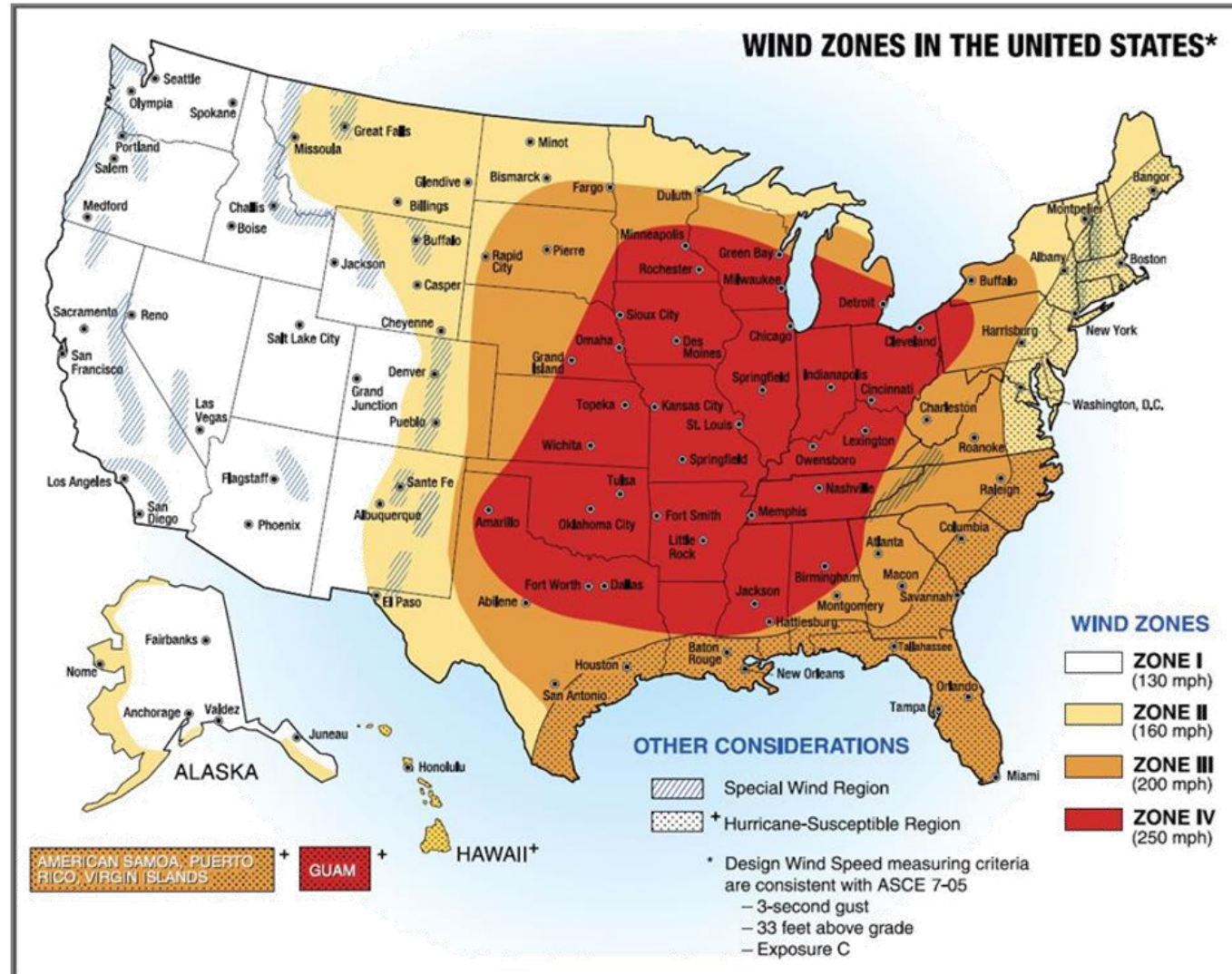
# Storm Shelters

- ICC 500 standard
  - Tornado and hurricane
- Dedicated – Group A-3
- Emergency shelters
  - Table 1604.5
  - Risk Category IV structures





# Storm Shelters



# Poll Question

4. Which of the following is classified as a Group I-2 occupancy?
- a. High School
  - b. Hospital
  - c. Office in a high-rise
  - d. Warehouse storing plastic cups



# Poll Question

5. In Type IIA construction what is the minimum fire-resistance rating for interior walls?
- a. 0 hours
  - b. 1 hour
  - c. 2 hours
  - d. 3 hours





# Poll Question

6. The maximum height of a building is controlled by type of construction type, occupancy classification, and the installation of fire sprinklers.
- a. True
  - b. False



# Poll Question

7. What is the allowable area for a non-sprinklered Type IIIB Group M occupancy without any frontage increase?
- a. 12,500
  - b. 18,500
  - c. 37,500
  - d. 50,000



# Poll Question

8. A building with multiple occupancies can be designed using which of the following methods?
- a. Accessory occupancies
  - b. Non-separated mixed-use occupancies
  - c. Separated mixed use occupancies
  - d. A combination of all of the above



# Poll Question

9. Hazardous materials are only allowed in Group H occupancies?
- a. True
  - b. False



# Discussion

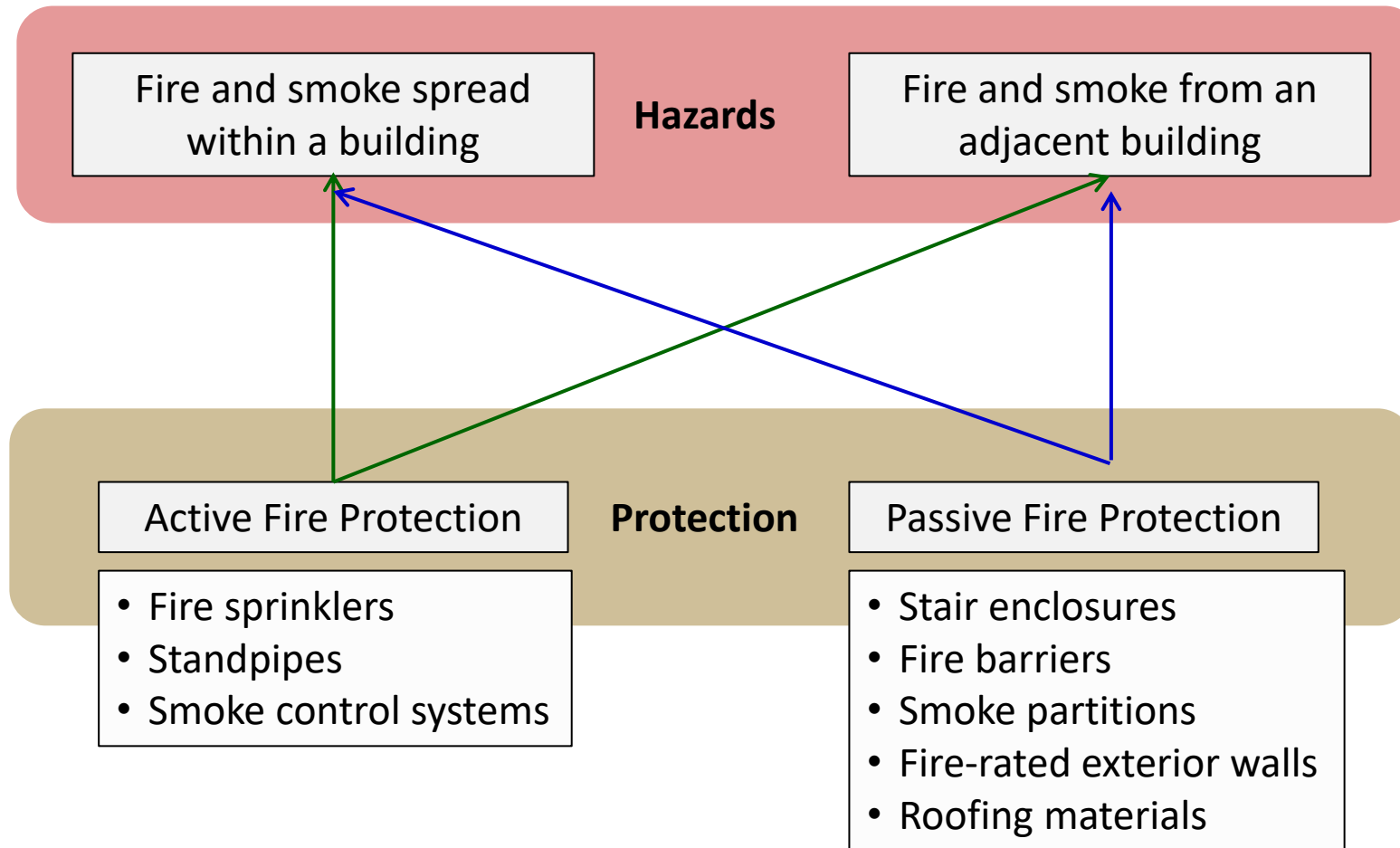


# Fire Safety



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# Spread of Fire and Smoke





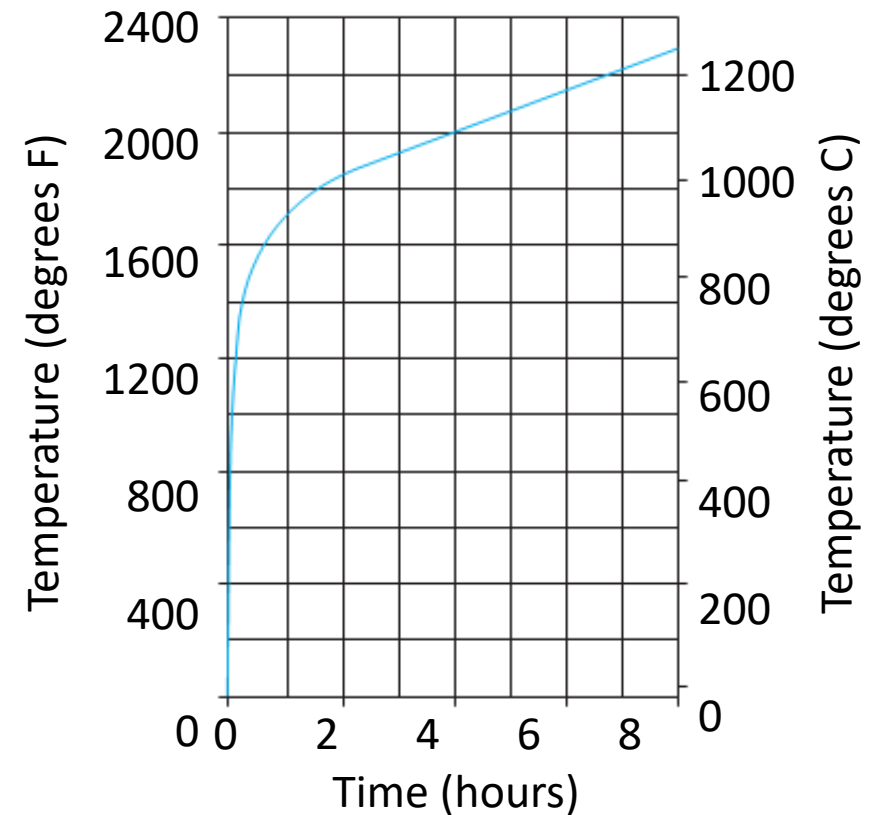
# Determining Fire Resistance

- Fire testing of assemblies and materials
- Prescriptive details
- Calculation based on specific materials



# Fire Testing

- Relative comparison between different construction methods and materials
- Standard Time-Temperature Curve
  - UL 263
  - ASTM E119



# Prescriptive Details

Material	Item number	Construction	Minimum finished thickness face-to-face (inches)			
			4 hours	3 hours	2 hours	1 hour
13. Noncombustible studs—interior partition with gypsum wallboard each side	13-1.1	0.018" (No. 25 carbon sheet steel gage) channel-shaped studs 24" on center with one full-length layer of $\frac{5}{8}$ " Type X gypsum wallboard applied vertically attached with 1" long No. 6 drywall screws to each stud. Screws are 8" on center around the perimeter and 12" on center on the intermediate stud. The wallboard may be applied horizontally when attached to $3\frac{5}{8}$ " studs and the horizontal joints are staggered with those on the opposite side. Screws for the horizontal application shall be 8" on center at vertical edges and 12" on center at intermediate studs.	—	—	—	$2\frac{7}{8}$
14. Wood studs—interior partition with gypsum wallboard each side	14-1.3	2" × 4" wood studs 24" on center with $\frac{5}{8}$ " Type X gypsum wallboard applied vertically or horizontally nailed with 6d cooler or wallboard nails at 7" on center with end joints on nailing members. Stagger joints each side.	—	—	—	$4\frac{3}{4}$

# Calculated Fire Resistance – Mass Timber

**Table 722.7.1(1).** Protection Required from Noncombustible Covering Material

Required Fire-Resistance Rating of Building Element per Tables 601 and 705.5 (hours)	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

**Table 722.7.1(2).** Protection Provided by Noncombustible Covering Material

Noncombustible Protection	Protection Contribution (minutes)
1/2-inch Type X gypsum board	25
5/8-inch Type X gypsum board	40

# Protection of the Structure

**Primary Structural  
Frame Members**

**Secondary Structural  
Frame Members**





# Protection of Structural Frame

- Masonry and concrete walls encase rebar and provide protection
- When required to provide a fire-resistance rating, exposed steel must be protected

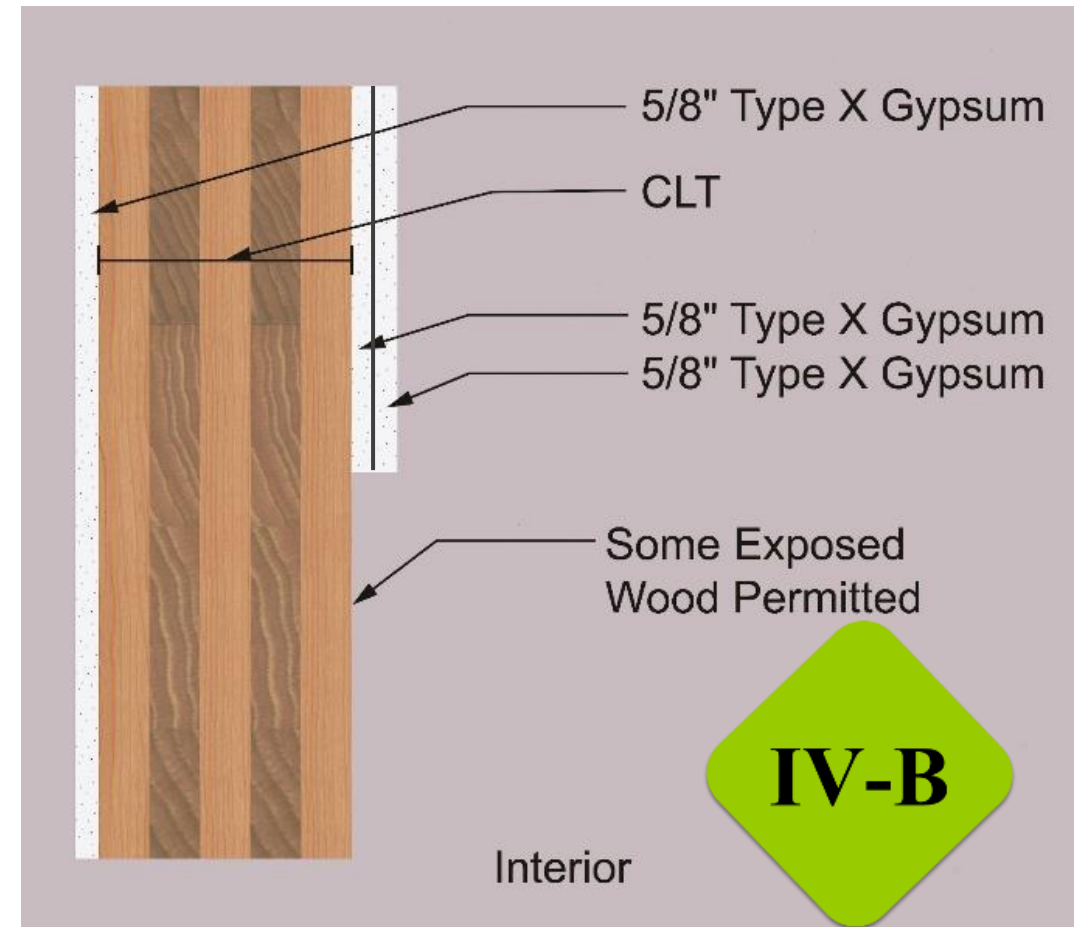
Sprayed fire-resistant material



# Protection of Structural Frame

## Mass Timber

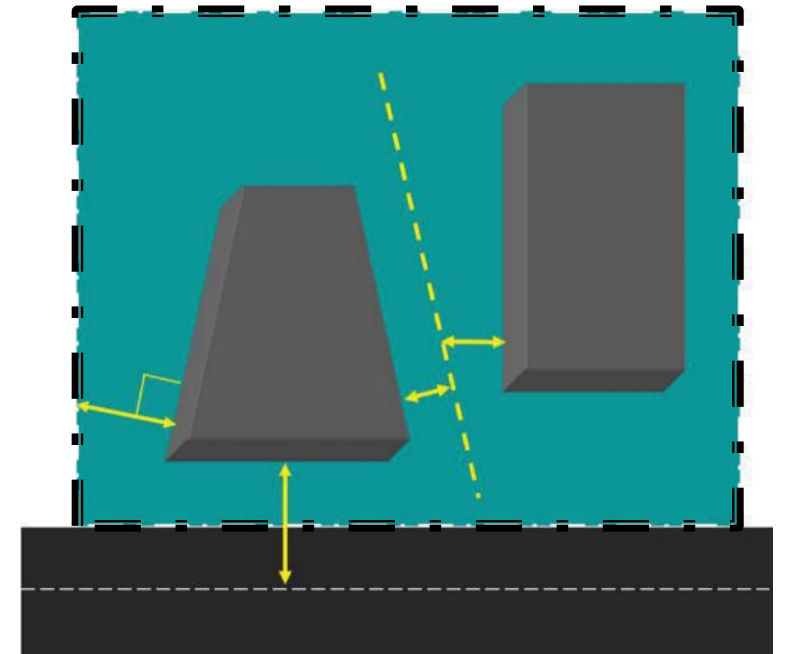
- Types IV-A, IV-B & IV-C
- $FRR_{Tot} = FRR_{MT} + FRR_{NC}$
- Exposed MT permitted in IV-B & IV-C





# Exterior Wall Protection

- Fire separation distance
  - Measured at right angles to walls
- Table 601 – based on construction type
- Table 705.5 – based on distance to property line

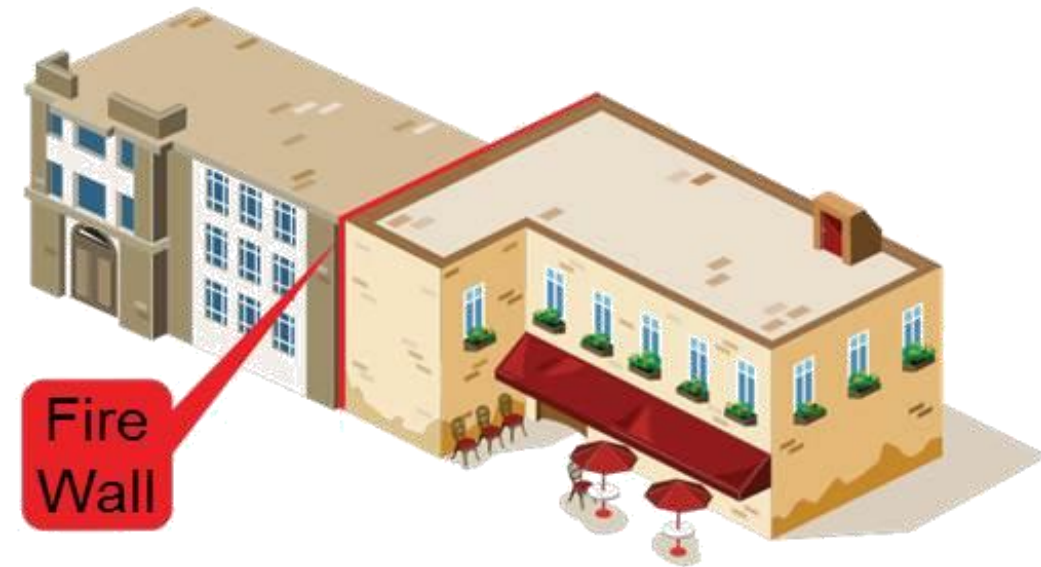


# Interior Fire-rated Walls

Fire Wall	Fire Barrier	Fire Partition
Building separation	Shafts & occupancy separation	Dwelling unit separation & corridors
Openings protected & limited	Openings protected & limited	Openings protected
Continuous from foundation through roof & exterior walls	Continuous from floor through concealed space at each level	Can terminate at fire-rated horizontal assembly
Structural stability		

# Fire Walls

- Structure on each side considered separate building for determining
  - Height and area
  - Construction type
- From foundation to  $\geq 30''$  above roof (alternatives)
- Extends  $\geq 18''$  beyond exterior walls (alternatives)
- Structural stability
  - Structure on either side can collapse but fire wall must remain for fire rating duration



# Fire Wall and Opening Ratings (hrs)

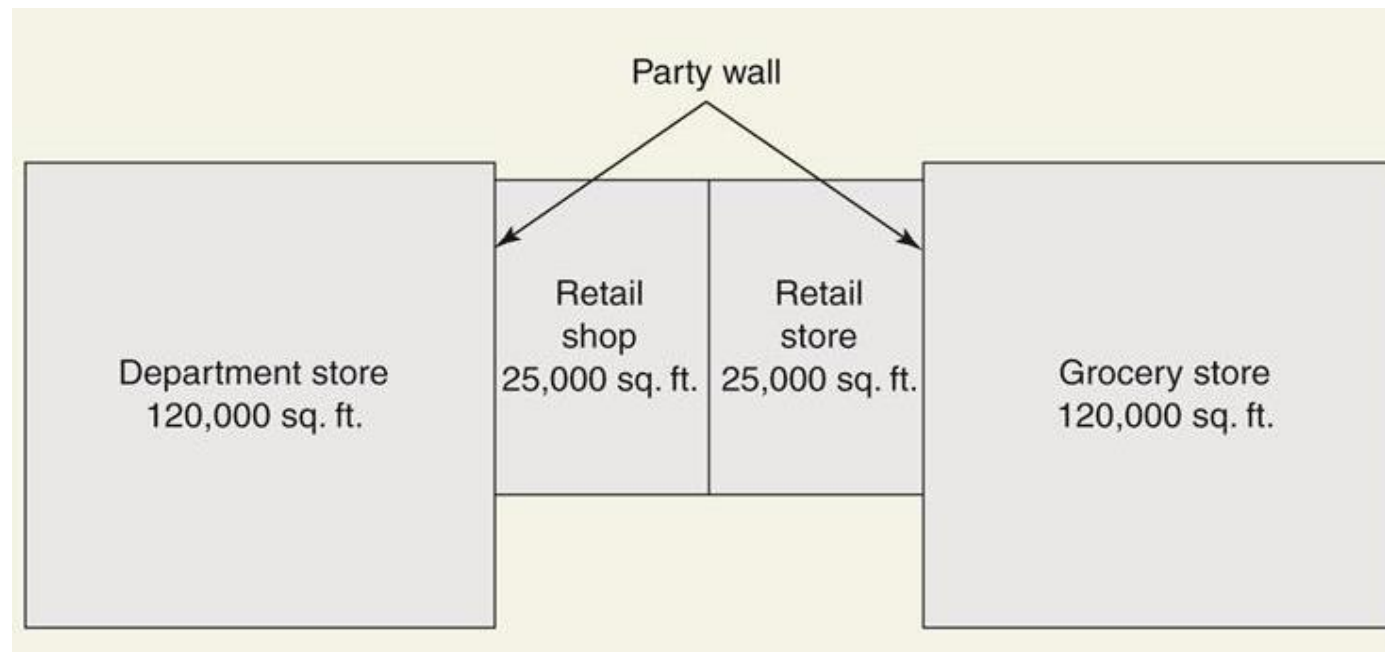
- Opening limits
  - Individual size  $\leq 156 \text{ ft}^2$
  - Aggregate width  $\leq 25\%$  of fire wall length

Group	Fire-resistance rating	Opening rating
A, B, E, H-4, I, R-1, R-2, U	3 <sup>a</sup>	3
F-1, H-3 <sup>b</sup> , H-5, M, S-1	3	3 <sup>c</sup>
H-1, H-2	4 <sup>b</sup>	3
F-2, S-2, R-3, R-4	2	1½

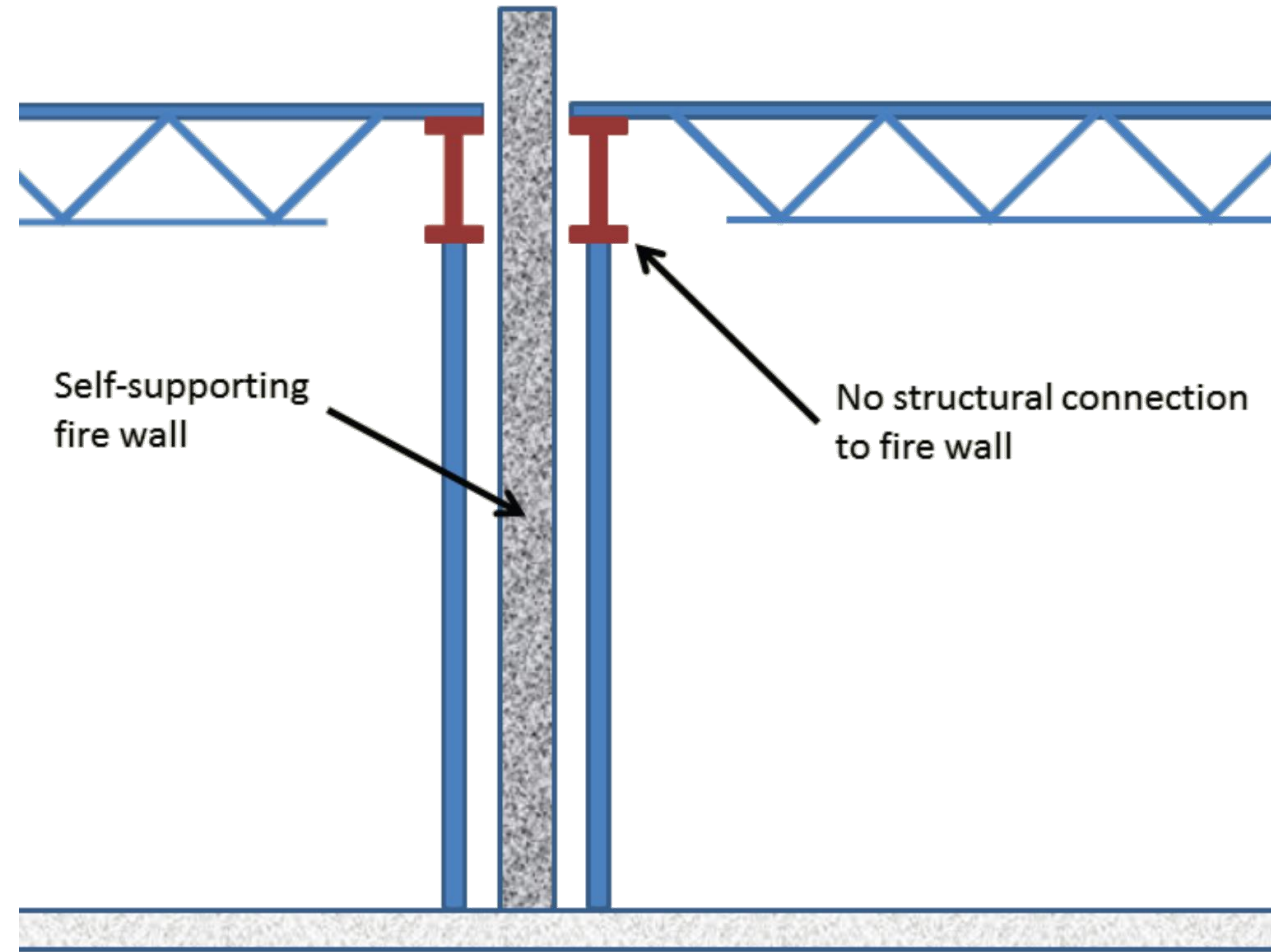
# Party Walls

Required on lot lines dividing building ownership

- Constructed as fire wall

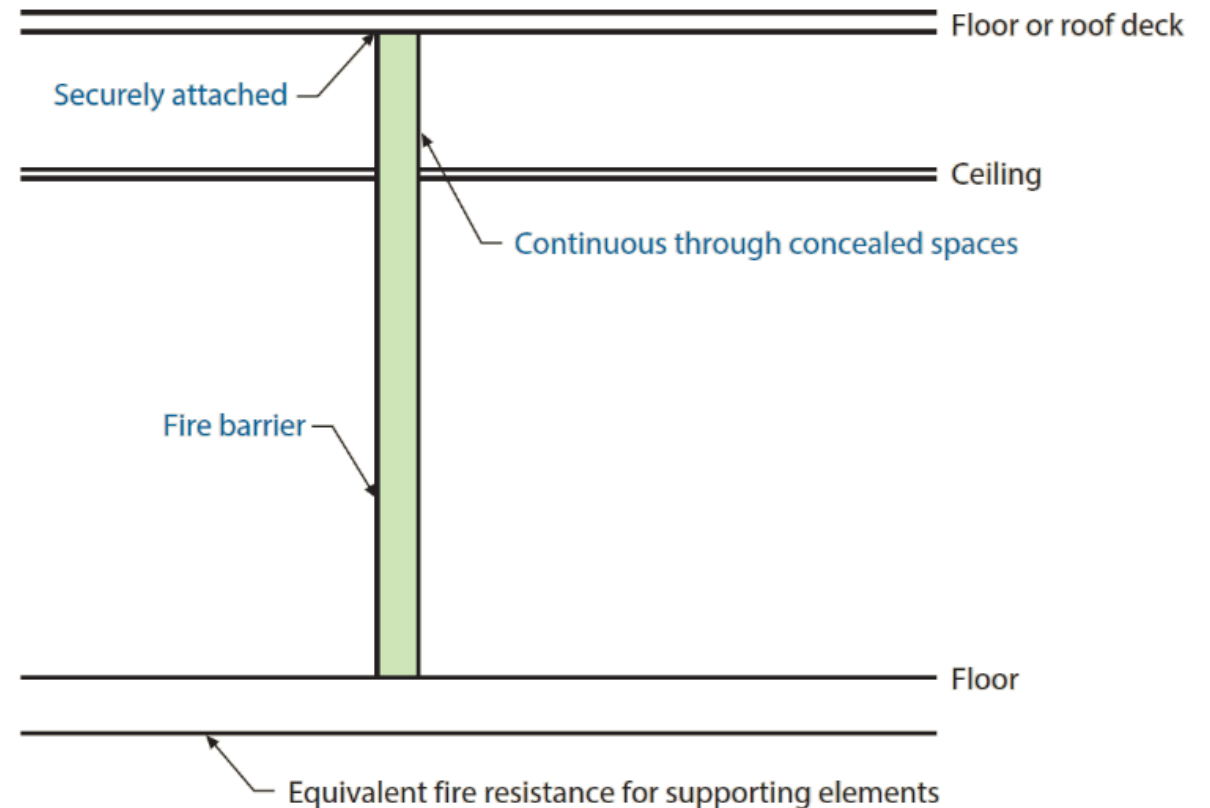


# Fire Wall Example



# Fire Barriers

- Examples
  - Shaft enclosures
  - Separation of fire areas
  - Separated occupancy
  - Incidental use
  - Control areas
- Supporting construction and structure requires fire-resistance rating equal to or better than fire barrier





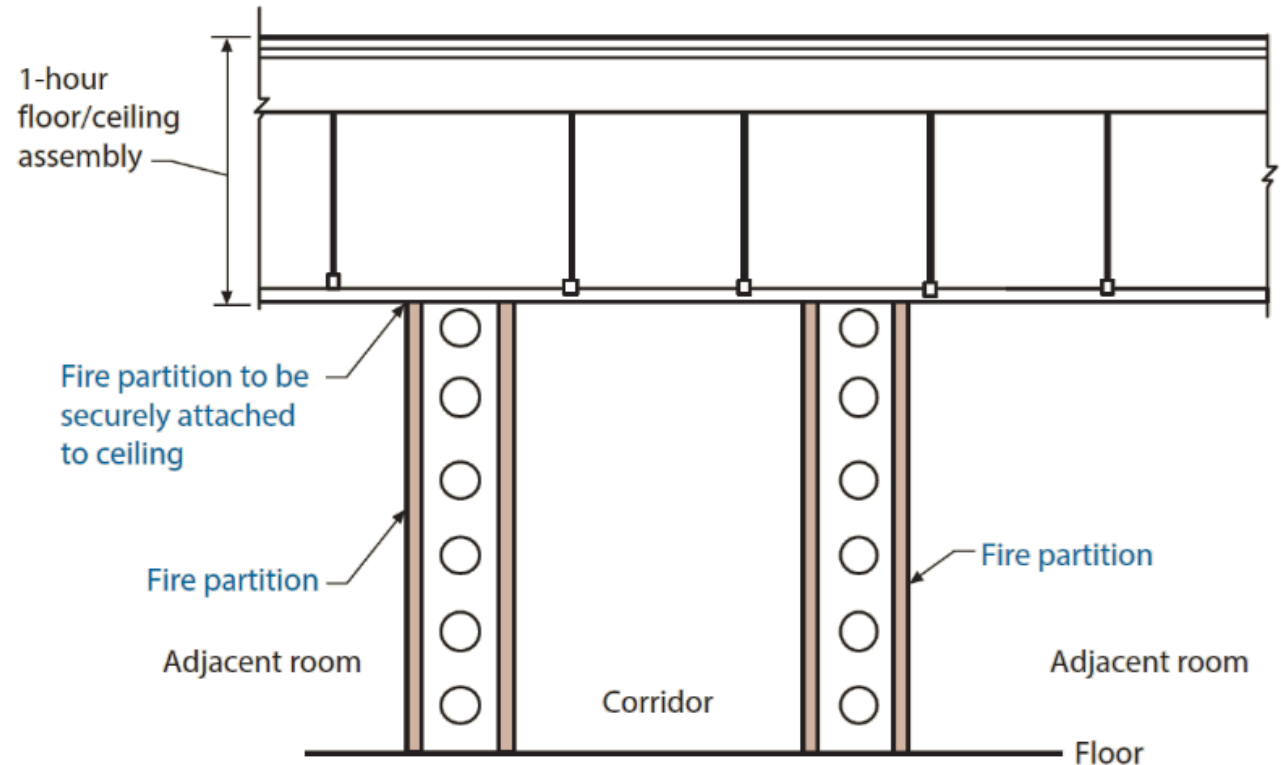
# Fire Barrier Opening Ratings (hrs)

FIRE BARRIER RATING	FIRE DOOR/SHUTTER RATING
4	3
3	3
2	1½
1	¾ <sup>a</sup>
[Ref. Table 716.1(2)]	

a. Openings in shafts, interior exit stairways and exit passageway walls are required to have a 1-hour fire rating.

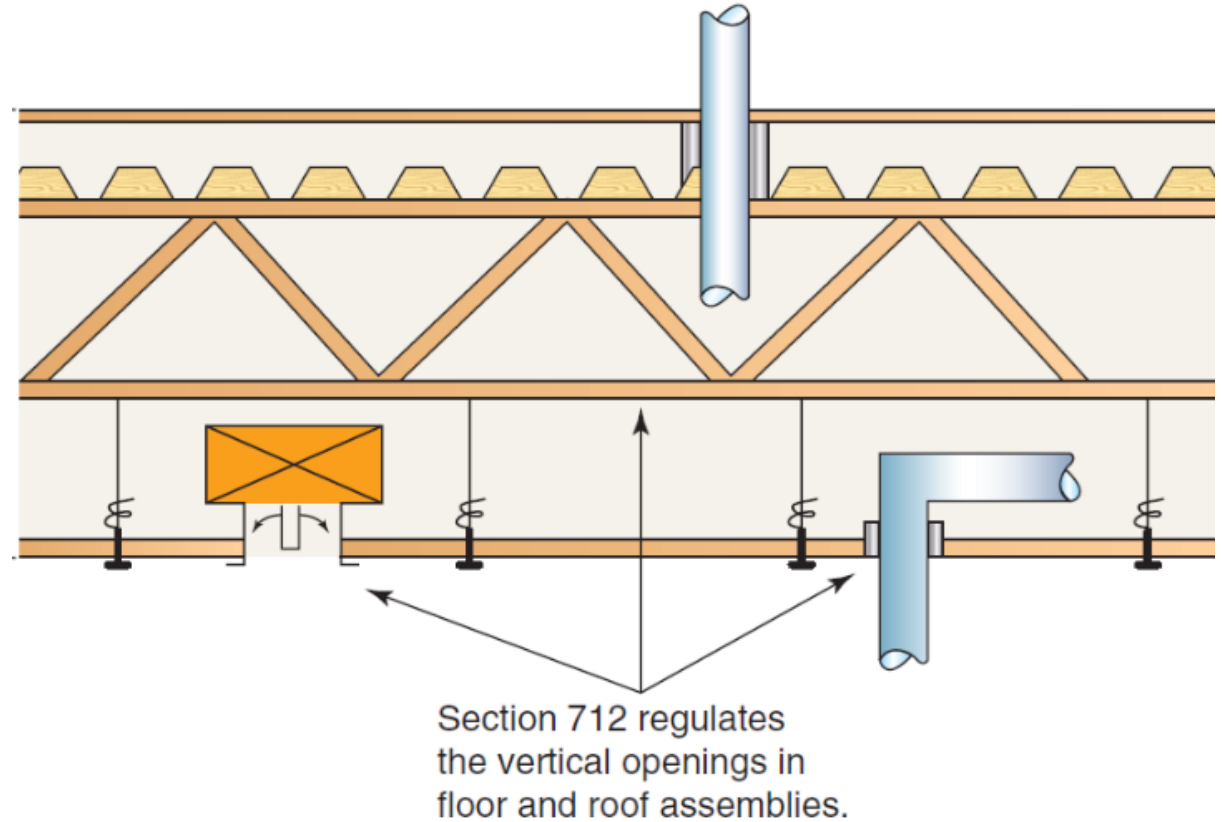
# Fire Partitions

- Separate
  - Dwelling/sleeping units
  - Mall tenant spaces
  - Rated corridor walls
  - Elevator lobbies
  - Egress balconies



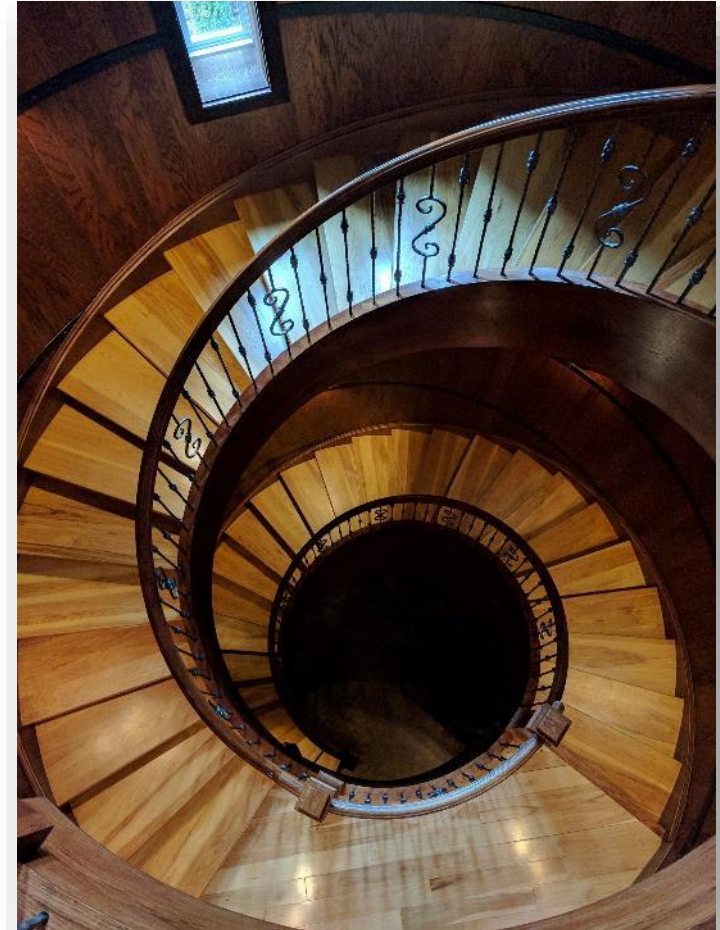
# Horizontal Assemblies

- Floor/ceiling assembly
- Roof/ceiling assembly
- Uses
  - Dwelling separation
  - Exit enclosure
  - Fire area separation
  - Mixed-use separation
  - Control area enclosure
  - Smoke barrier enclosure



# Vertical Openings

- Shaft enclosures
- Escalators
- Penetrations
- Joints
- Ducts
- Atriums
- Chimneys
- Mezzanines
- Skylights



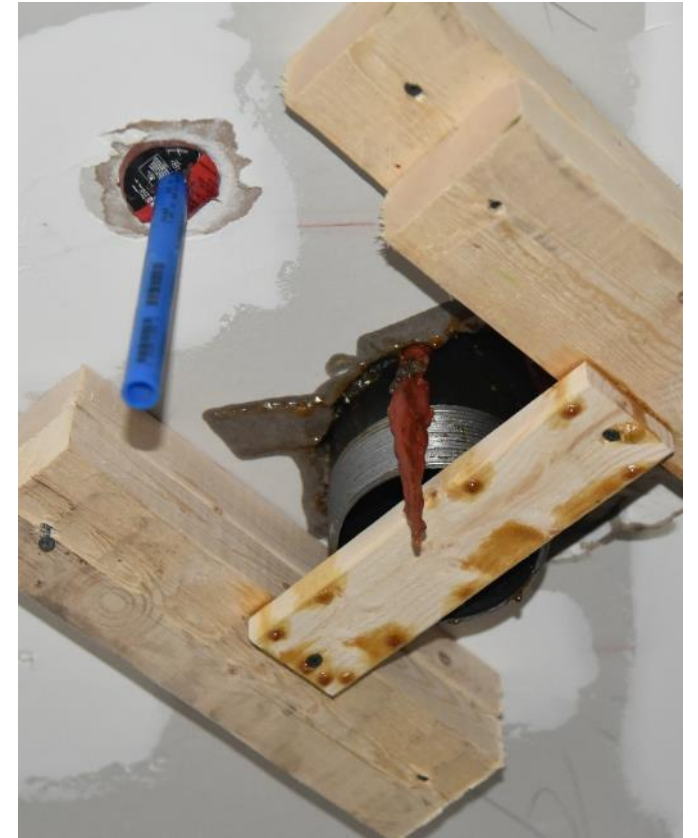
# Shaft Enclosures

- Fire-resistance rating
  - 1-hr if connecting  $> 2$  stories
  - 2-hr if connecting  $\geq 4$  stories
- Fire barrier construction
  - Continuity
- Openings and penetrations protected



# Penetrations

- Pipes, tubing, conduit, and cables passing through fire assemblies
- Through penetrations
  - Entire assembly
- Membrane penetrations
  - One surface
- Listed penetration firestop system installed per manufacturers' instructions



# Opening Protection

- Doors and windows installed in fire-resistance-rated assemblies require fire protection rating
- Fire door assemblies include door, frame and all associated hardware





# Interior Finish Requirements

- Flame spread is the propagation of flame over a surface

Group	Sprinklered			Nonsprinklered		
	Exit enclosures/ passageways	Corridors	Rooms & enclosed space	Exit enclosures/ passageways	Corridors	Rooms & enclosed space
A-1 & A-2	B	B	C	A	A	B
A-3, A-4, A-5	B	B	C	A	A	C
B, E, M, R-1	B	C	C	A	B	C
R-4	B	C	C	A	B	B
F	C	C	C	B	C	C
H	B	B	C	A	A	B
I-1	B	C	C	A	B	B
I-2 & I-4	B	B	B	A	A	B
I-3	A	A	C	A	A	B
R-3	C	C	C	C	C	C
R-2 & S	C	C	C	B	B	C
U	No restrictions			No restrictions		

# Interior Finish Requirements

Class	Flamespread Index
A	0-25
B	26-75
C	76-200

MATERIAL	FLAME SPREAD
Red or White Oak	100
Douglas-fir	90
Western Red Cedar	69
Plywood paneling (untreated)	75 to 275
Plywood paneling (treated)	100
Gypsum board	10 to 25
Concrete or brick	0
Carpeting	10 to 600

# Fireblocking

- Cuts off
  - Concealed openings
  - Openings between walls and floors or attics
  - Floor levels
  - Top floor and attic
- Required in wall spaces
  - Vertically at ceiling and floor
  - Horizontally at intervals  $\leq 10'$



# Draftstops

- Large concealed floor spaces and attics with combustible construction ( $\leq 1,000 \text{ ft}^2$ )
- Attics, mansards and concealed roof spaces subdivided into maximum  $3,000 \text{ ft}^2$ 
  - Fire sprinklers in these spaces eliminate requirement
- Group R exceptions



# Automatic Fire Sprinklers

- React to heat
- Apply water directly to fire area
- Normally operate independently

Stage 1



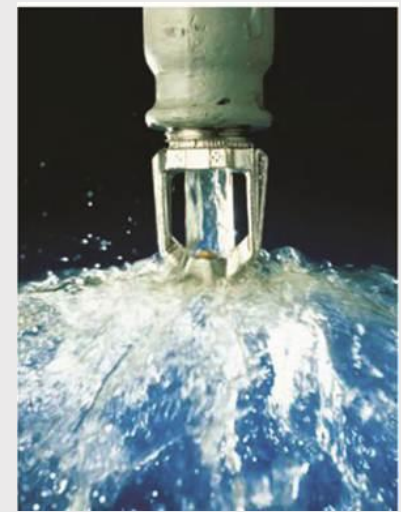
Stage 2



Stage 3

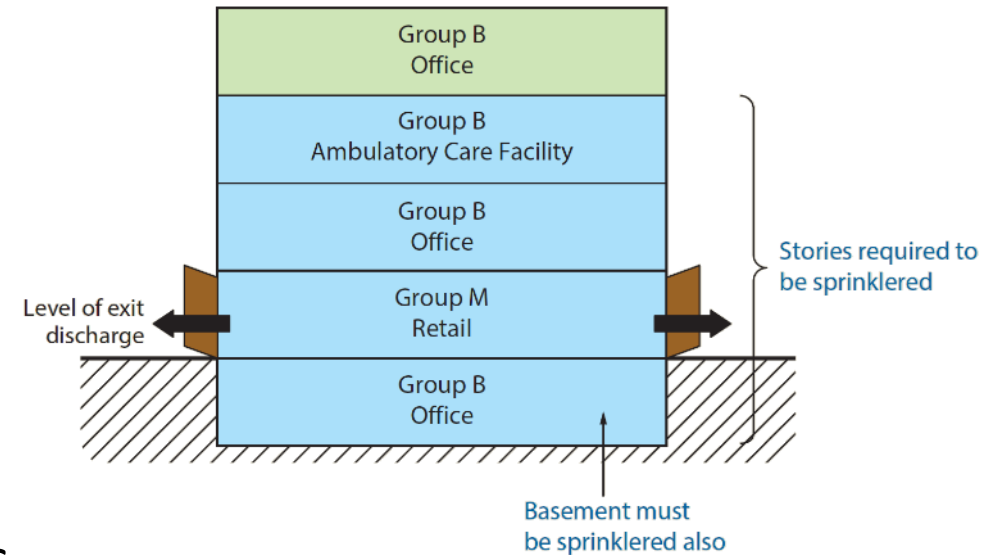


Stage 4

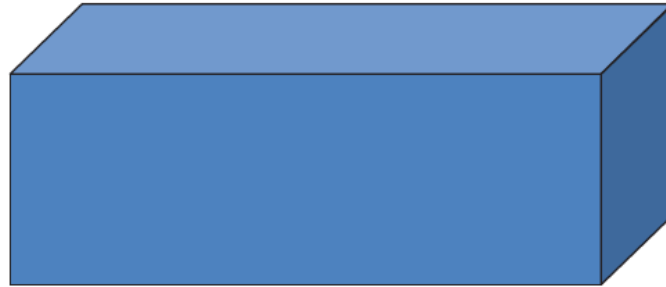


# Automatic Fire Sprinklers

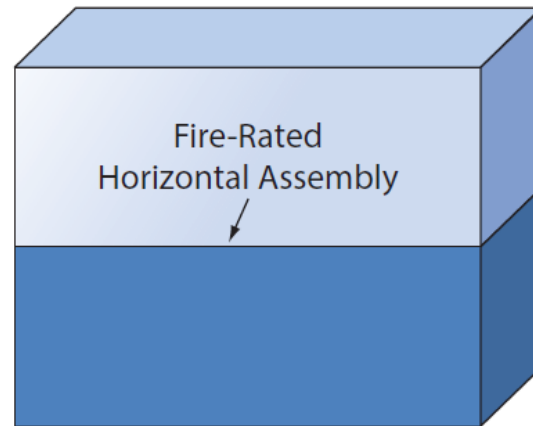
- Required based on
  - Occupancy classification
  - Use or materials handled
  - Number of occupants
  - Fire areas
  - Floor level in building
- Also required in
  - Buildings with no exterior wall openings
  - Rubbish/linen chutes



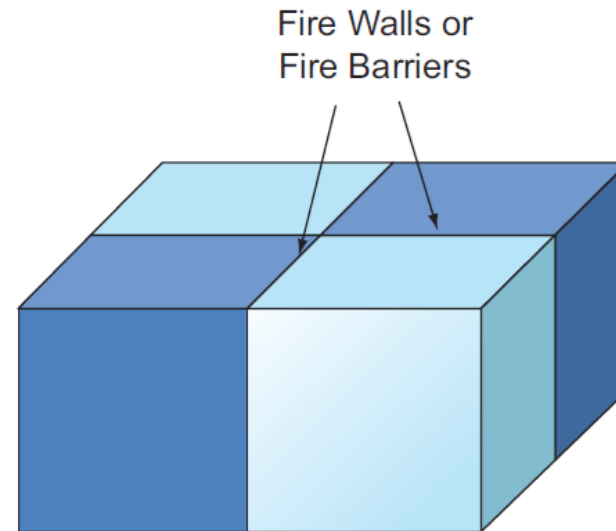
# Fire Areas



Building is a Single Fire Area



Two Fire Areas Created by Horizontal Assembly



Four Fire Areas Created by Fire Walls or Fire Barriers

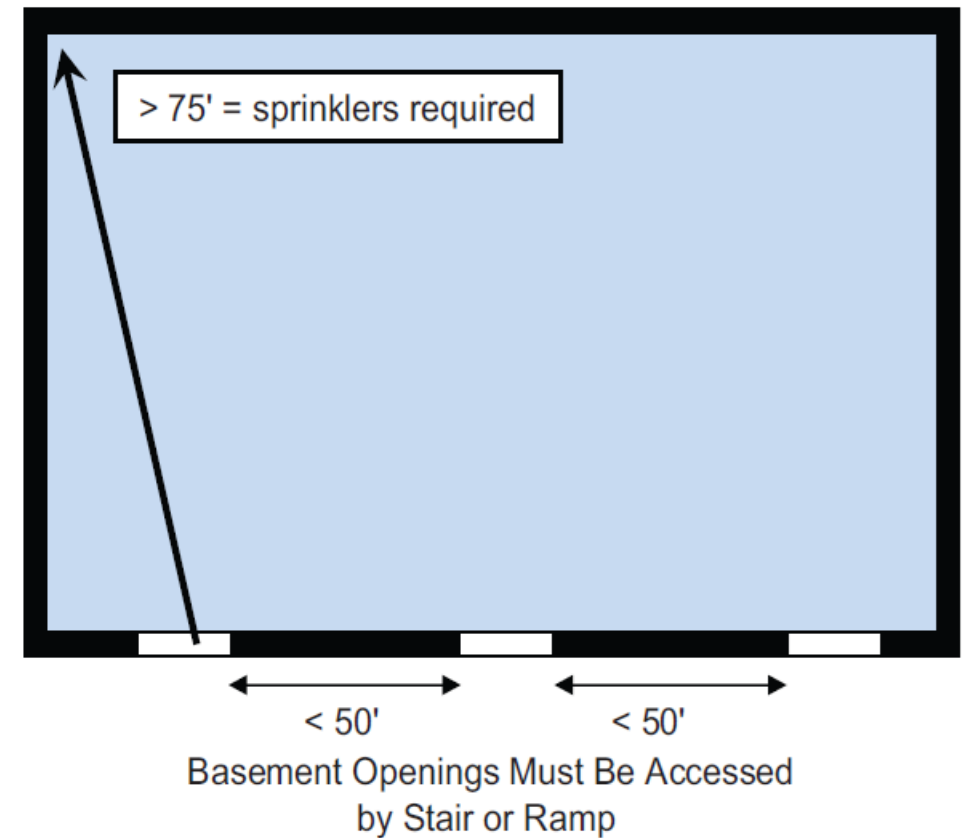
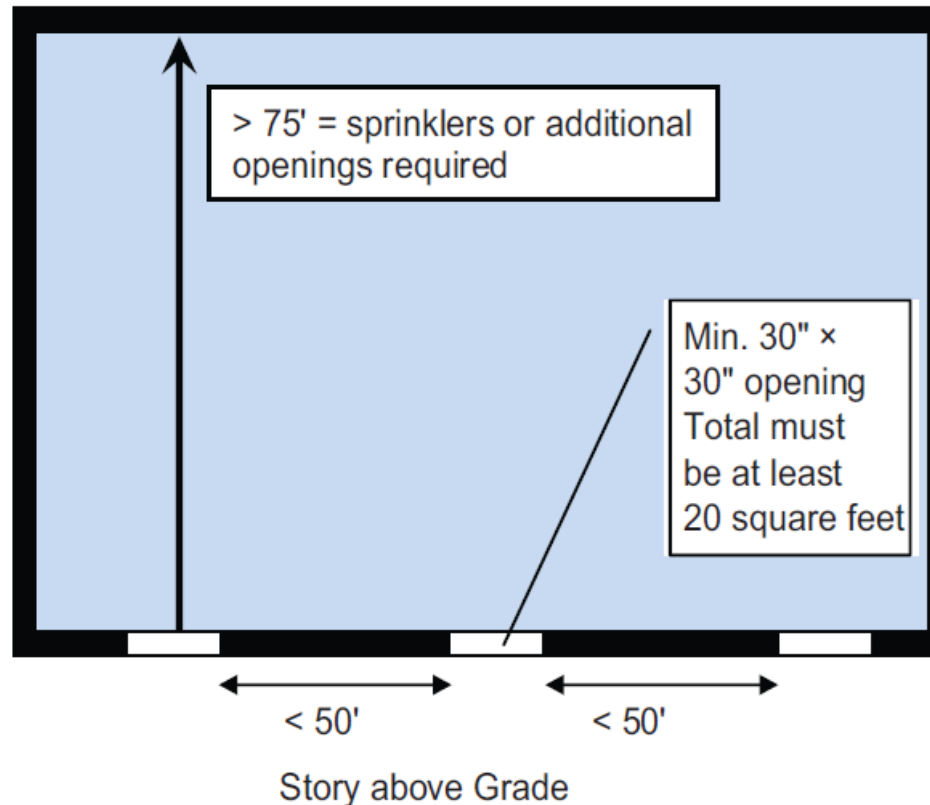


# Fire Areas

- Created with  $\geq 1$ -hr fire-resistance-rated construction
- Single occupancies separated into smaller fire areas eliminate sprinklers

OCCUPANCY GROUP	FIRE-RESISTANCE RATING (hours)
H-1, H-2	4
F-1, H-3, S-1	3
A, B, E, F-2, H-4, H-5, I, M, R, S-2	2
U	1
[Ref. Table 707.3.10]	

# Automatic Fire Sprinklers – Stories without Openings



# Automatic Fire Sprinkler Credits

- Credit and modifications allowed for added protection sprinkler systems provide
- Standards
  - NFPA 13
  - NFPA 13R
  - NFPA 13D



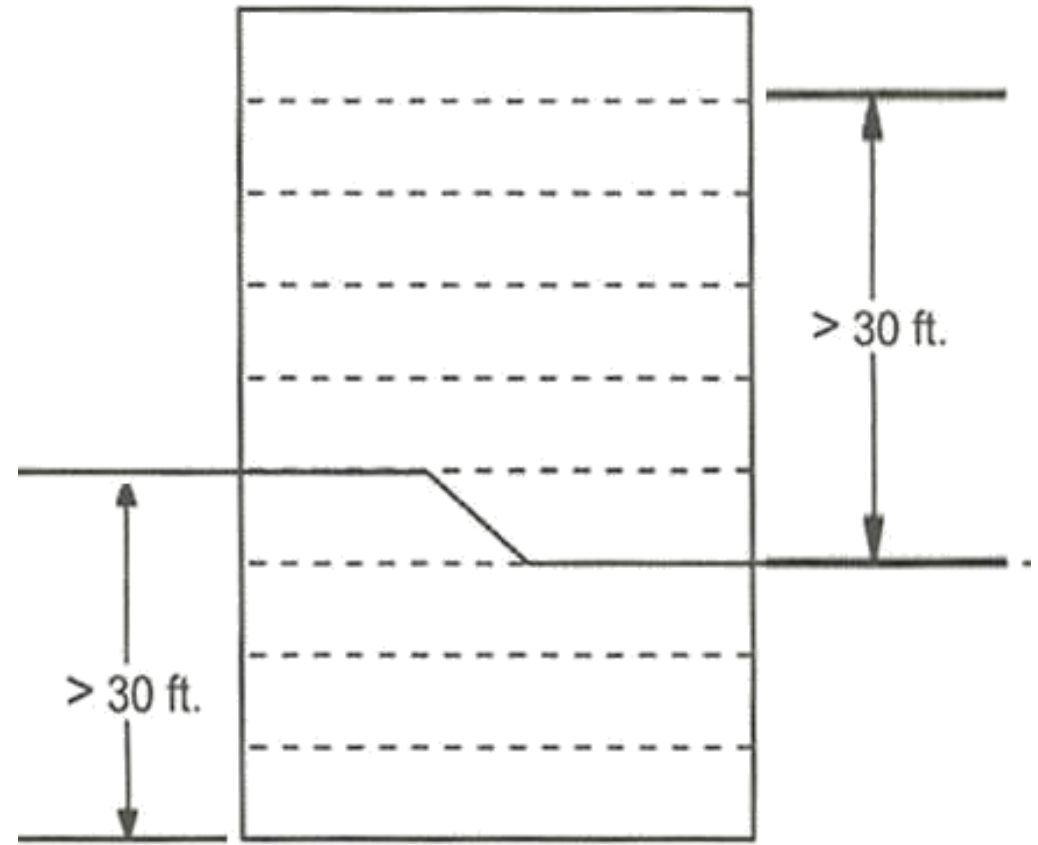
# Standpipes

- Classes
  - Class I – 2½” connection for FD
  - Class II – 1½” connection with hose
  - Class III – combination of both I & II
- Types
  - Wet standpipe
  - Dry standpipe
- Must comply with NFPA 14



# Standpipes

- In buildings with a floor level
  - >30 feet above LLFDVA
  - >30 feet below HLFDA
- Covered malls
- Stages



# Fire Alarm Systems

- Activation
  - Manual
  - Automatic
- Required based on
  - Occupancy classification
  - Occupant load
  - Floor level
  - Operations conducted
  - Materials handled
- Must comply with NFPA 72



# Fire Alarm Systems

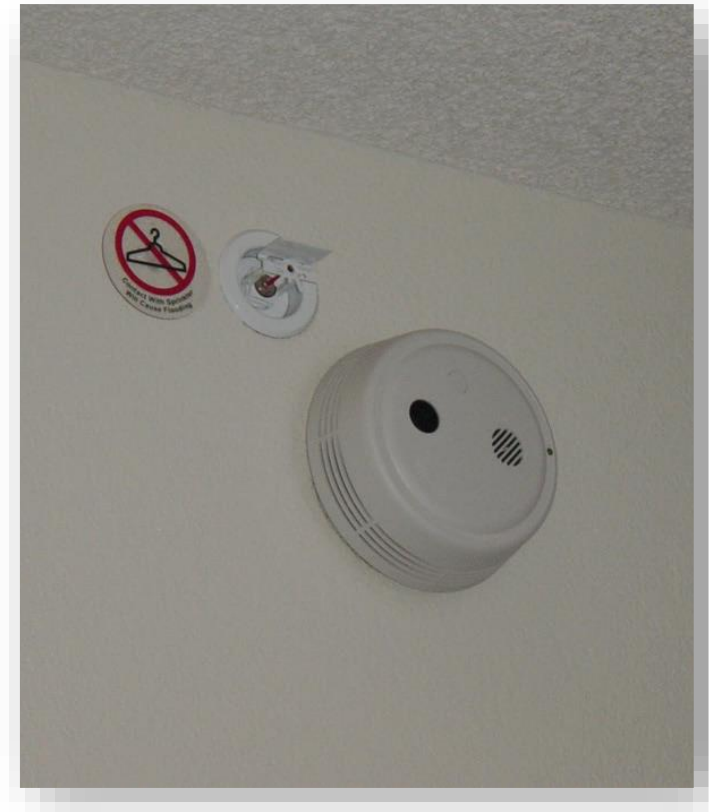
- Occupant notification
  - Audible
    - 15 dBA above ambient
    - 5 dBA above max 60 second sound level
    - Maximum 110 dBA
  - Visual
    - Public and common areas
  - Emergency voice/alarm communication system
    - Provide voice instructions





# Smoke Alarms

- Per UL 217 & NFPA 72
- Multiple units interconnected so when one device senses smoke all devices sound-off
- Required in
  - R-1 – sleeping areas, egress path and each floor
  - R-2, R-3, R-4, I-1 – sleeping rooms, common area outside of sleeping rooms and each floor



# Smoke Control Systems

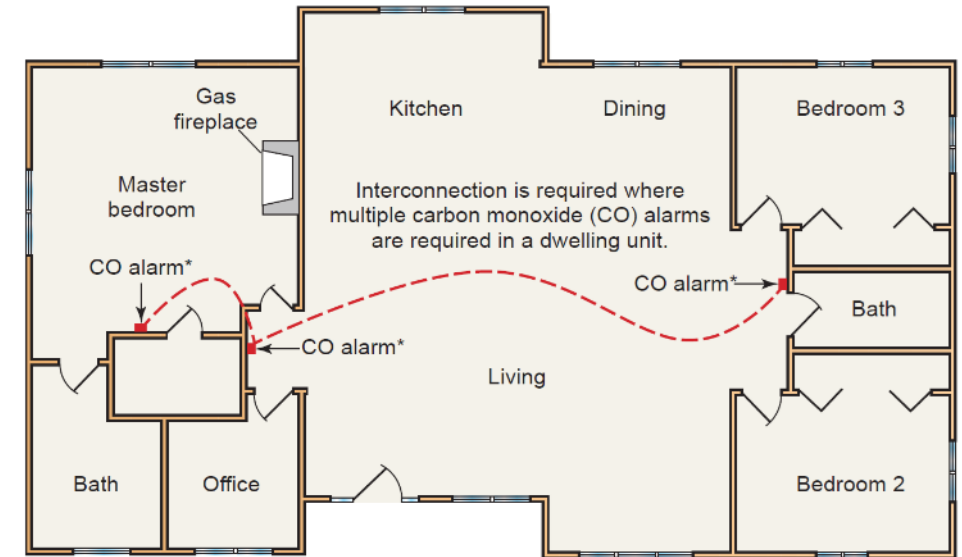
- Smoke barriers
  - Restrict passage of smoke
  - 1-hr fire-resistance rated
- Smoke-protected assembly seating
- Smoke control system
  - Mall or atrium with 3 levels
  - Underground buildings
  - Large arenas



Cross-corridor doors with magnetic hold-open device released by smoke detectors or fire alarm

# Carbon Monoxide Alarms

- Group E, I-1, I-2, I-4 and R occupancies with
  - Fuel-burning appliance
  - Attached garage
- Installed
  - Immediate vicinity of bedrooms
  - Every occupied level
    - Including basements
    - Excluding attics & crawl spaces



# Poll Question

10. A 3-hr fire-resistance-rated fire wall is required to separate two Group M occupancies.
- a. True
  - b. False



# Poll Question

11. A door in a 2-hr fire-resistance-rated fire barrier must have a minimum fire-resistance rating of \_\_\_\_\_ hours.
- a.  $\frac{3}{4}$
  - b. 1
  - c.  $1\frac{1}{2}$
  - d. 2



# Poll Question

12. The flame spread index of interior finishes placed into the corridor of a sprinklered Group A-2 restaurant must be at least Class \_\_\_\_\_ .
- a. A
  - b. B
  - c. C
  - d. No restriction



# Poll Question

13. Fire area, rather than building area, is used to determine the size of occupancies when fire sprinklers are required.
- a. True
  - b. False





# Poll Question

14. Fire sprinklers may be required based on which of the following criteria?
- a. Occupancy classification
  - b. Use or materials handled
  - c. Number of occupants
  - d. Size of fire areas
  - e. Floor level in the building
  - f. Any of the above



# Poll Question

15. A Group I-1 Assisted Living Facility with an attached garage must be equipped with both smoke alarms and carbon monoxide alarms?
- a. True
  - b. False



# Discussion



# Life Safety



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# Egress System Design

## Areas without fixed seating

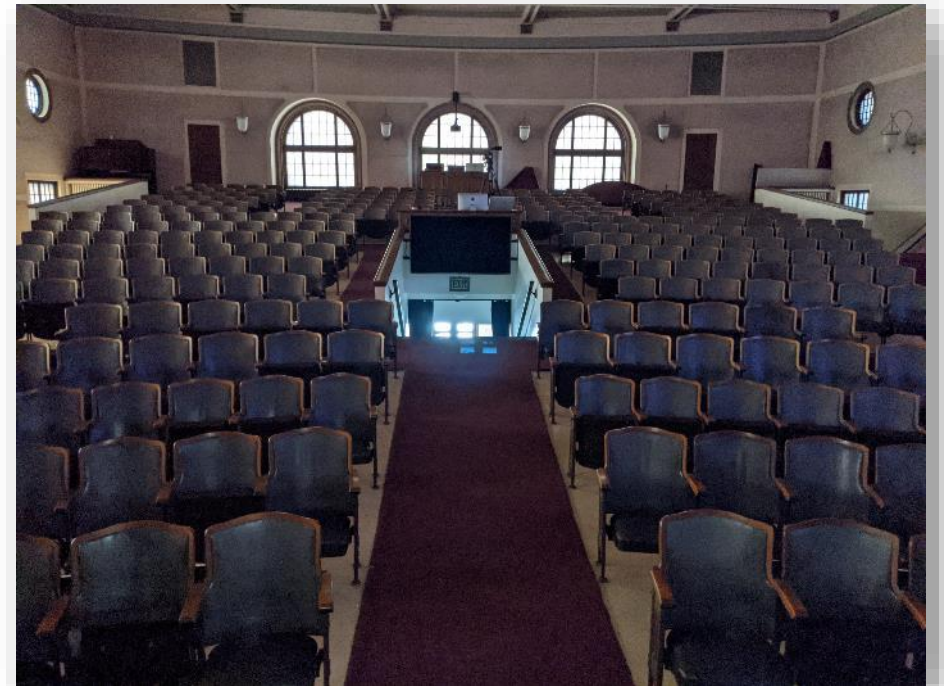
- Occupant load =  $\text{Area} / \text{OLF}$
- Gross
- Entire floor area excluding vent shafts and courts
- Net
- Actual occupied area

## Occupant Load Factor (OLF)

FUNCTION OF SPACE	FLOOR AREA IN SQ. FT. PER OCCUPANT
Assembly without fixed seats	
Concentrated (chairs only—not fixed)	7 net
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Business areas	150 gross
Kitchens, commercial	200 gross
Mercantile	60 gross
Storage, stock, shipping areas	300 gross
Residential	200 gross
Warehouses	500 gross
[Ref. Table 1004.5]	

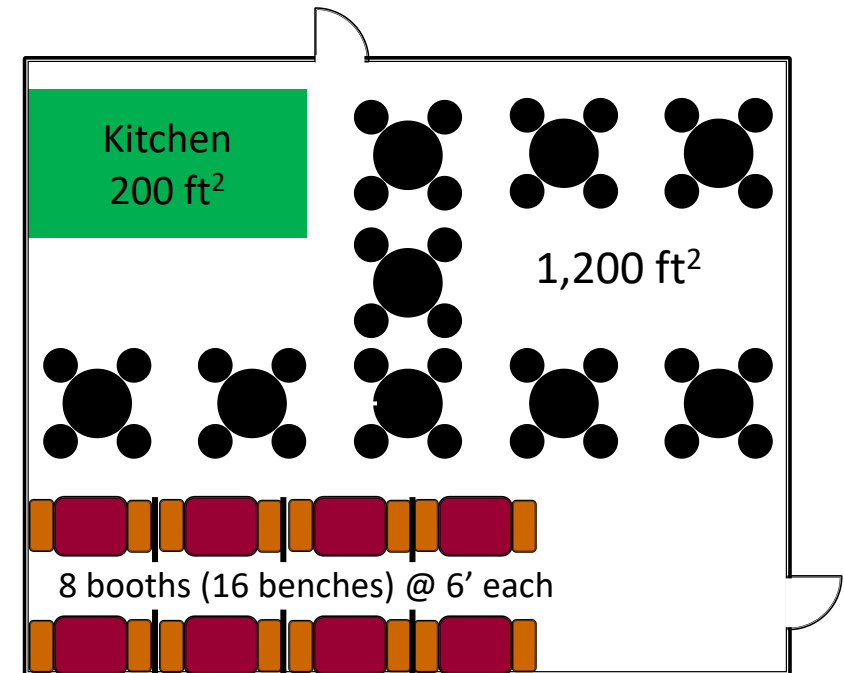
# Egress System Design

- Areas with fixed seating
  - Occupant load based on number of fixed seats
  - Benches
    - Pews = 18"/person
    - Dining = 24"/person



# Occupant Load Calculation

- Restaurant with 1,200 ft<sup>2</sup> of chairs and booths
- 8 booths (16 benches) – 6' wide each
- 200 ft<sup>2</sup> kitchen
  - Kitchen  $200/200 = 1$
  - Dining Area  $1,200/15 = 80$
  - Booths  $6'/24" = 3/\text{bench} = 48$
  - Total  $1 + 80 + 48 = 129$





# Exits from Spaces

- Each room or space is evaluated
- Exit access is 1<sup>st</sup> portion of egress system
- Minimum of 2 exits required
  - Limited occupancy allows one exit

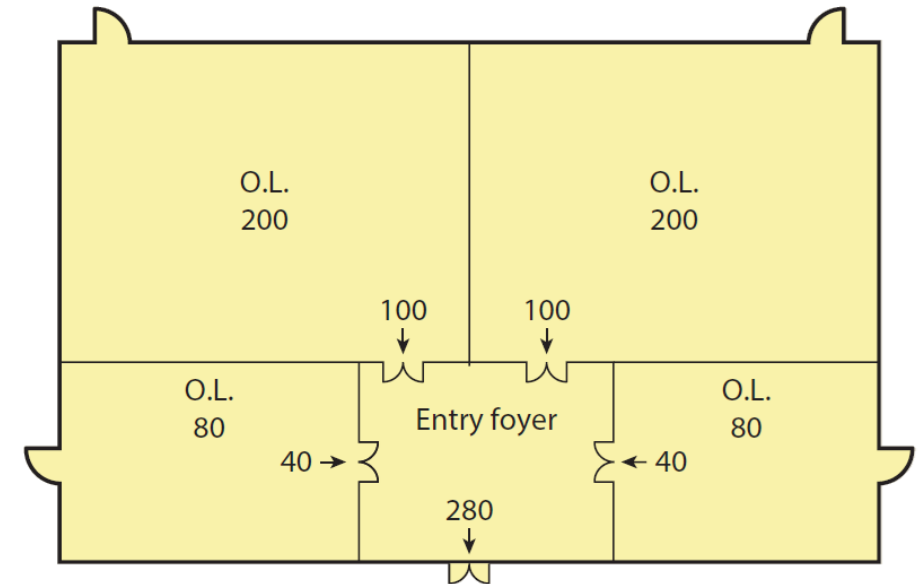
**Spaces with One Exit or Exit Access Doorway**

<b>OCCUPANCY</b>	<b>MAXIMUM OCCUPANT LOAD</b>
A, B, E, F, M, U	49
H-1, H-2, H-3	3
H-4, H-5, I, R-1	10
R-2, R-3, R-4	20
S	29

[Ref. Table 1006.2.1]

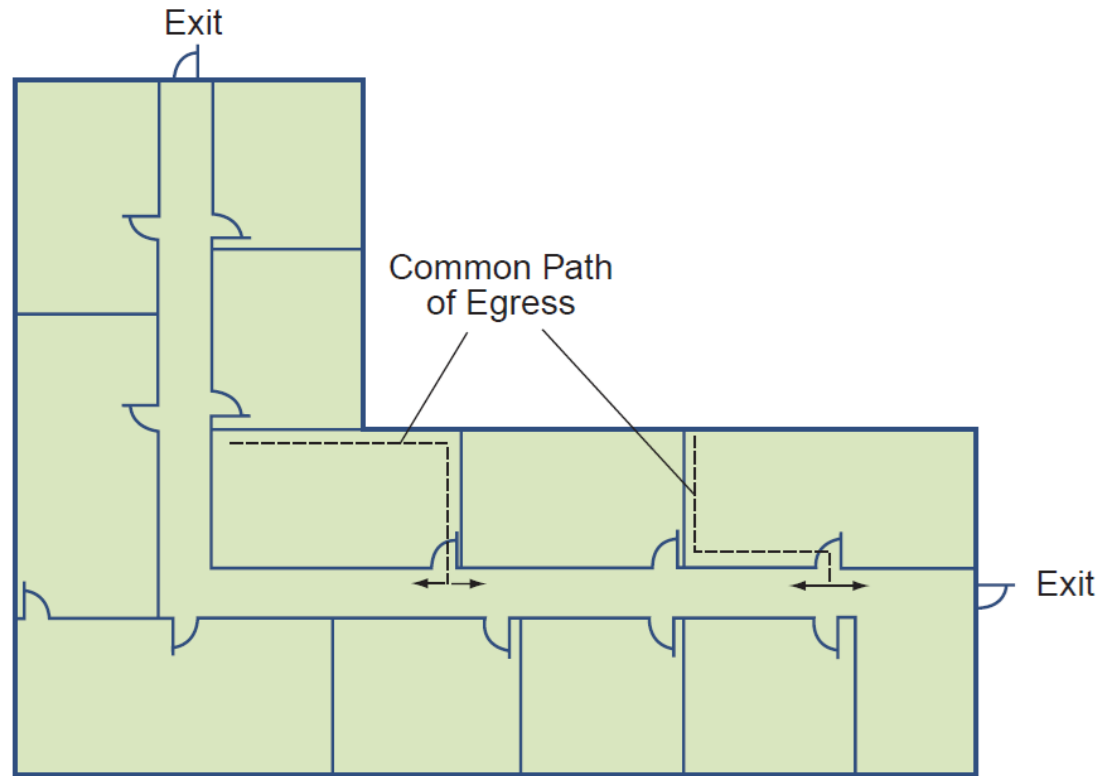
# Number of Exits

- Additional exits required if occupant load
  - 501-1,000 requires  $\geq 3$  exits
  - $>1,000$  requires  $\geq 4$  exits
- Also evaluated
  - Each floor
  - Entire building
  - Each use



# Common Path of Egress Travel

Multiple exits based on travel distance



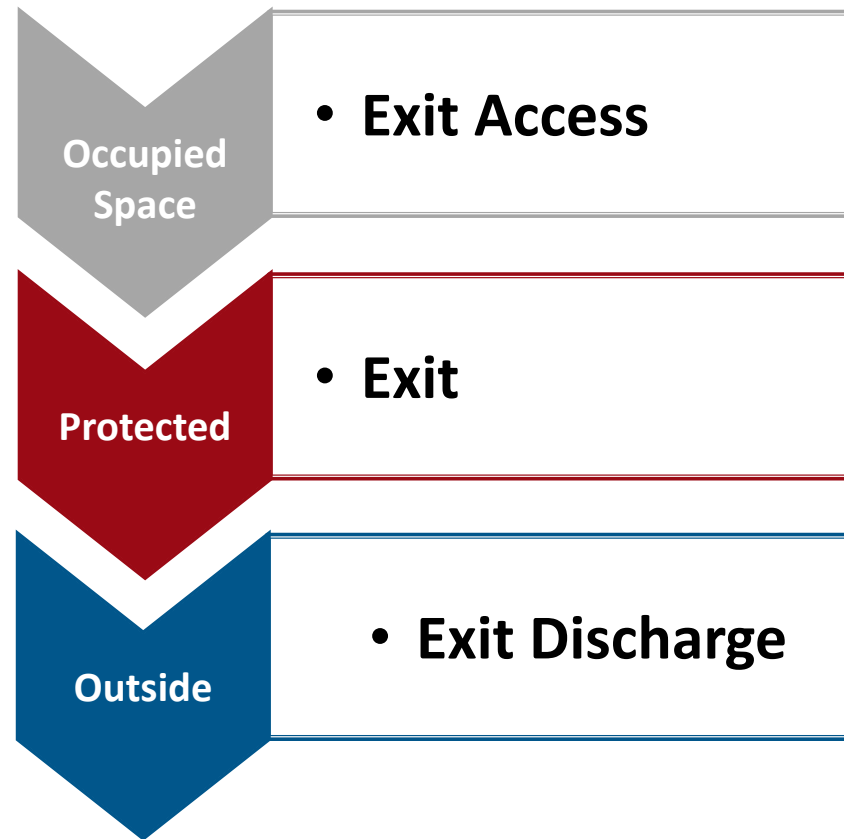
# Common Path of Egress Travel

OCCUPANCY	WITHOUT SPRINKLER SYSTEM (FEET)		WITH SPRINKLER SYSTEM (FEET)
	Occupant load		
	OL ≤ 30	OL > 30	
A, E, M	75	75	75
B	100	75	100
I-1, I-2, I-4	NP	NP	75
R-2	NP	NP	125
S	100	75	100

[Ref. Table 1006.2.1]

OL = Occupant load; NP = Not permitted

# Means of Egress (MOE) Systems



# Exit

Occupants either

- Leave the building
- Enter protected egress path
  - Stair enclosure
  - Exit passageway
  - Horizontal exit



# Exit Discharge

- From exit to public way
- At grade or direct access to grade
- Access public way without obstructions





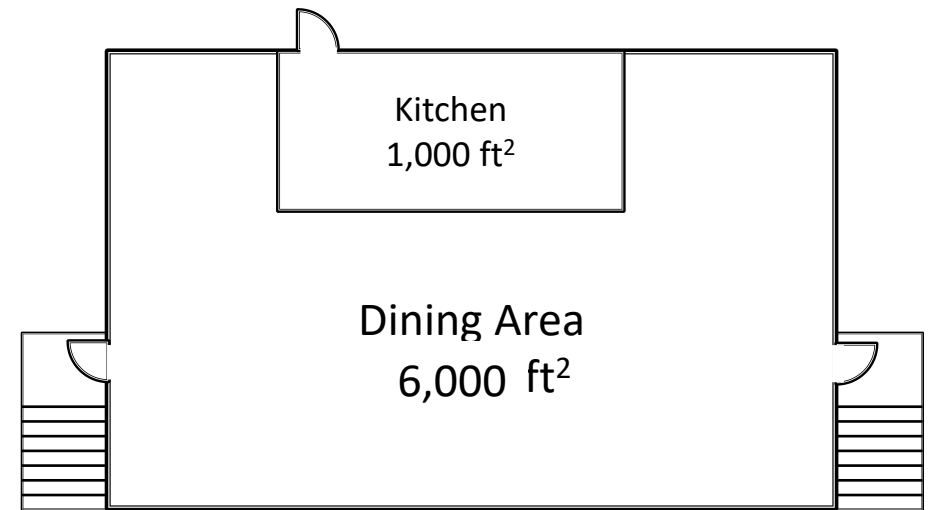
# Making it Wide Enough

- Egress doors/corridors/paths
  - Occupant Load x 0.2"
- Stairs
  - Occupant Load x 0.3"
- If one path lost total width  $> \frac{1}{2}$
- Maintained to public way
- Reductions for
  - Sprinklers
  - EV/AC



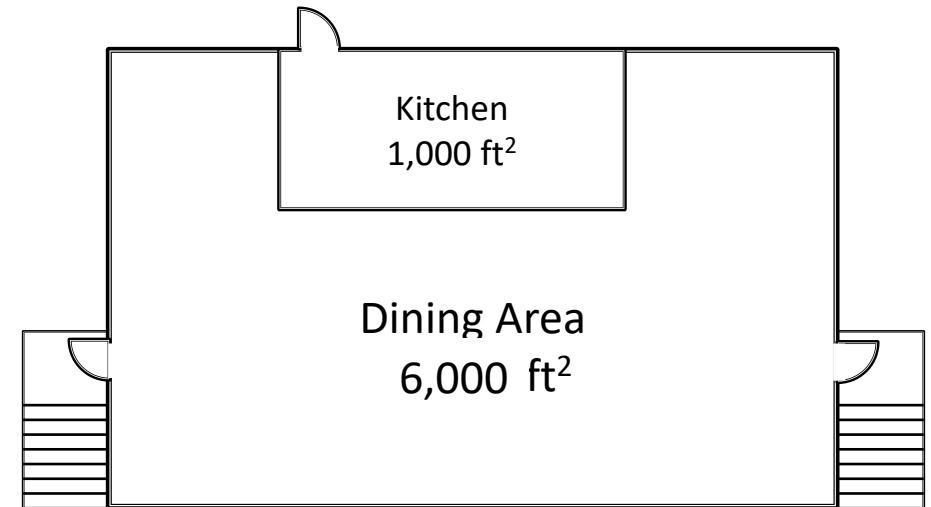
# Exit Width Calculation

- 6,000 ft<sup>2</sup> dining area
- Determine Dining Occupant Load
  - $6,000 \text{ ft}^2 \div 15 \text{ ft}^2/\text{occupant} = 400 \text{ occupants}$
- Determine exit path width
  - $400 \times 0.2''/\text{occupant} = 80''$
  - Minimum 2 exits required
  - 3'-0" doors installed
  - 3 doors = 108"
- Determine stair width
  - $400 \times 0.3''/\text{occupant} = 120''$
  - 2 stairs  $\geq 60''$  each



# Exit Width Calculation

- Add Sprinklers and EV/AC
  - Exit path width
    - $400 \times 0.15''/\text{occupant} = 60''$
    - Minimum 2 exits required
    - Clear door width  $\geq 32''$
    - 2 doors = 64''
  - Stair width
    - $400 \times 0.2''/\text{occupant} = 80''$
    - 2 stairs  $\geq 44''$  width = 88''



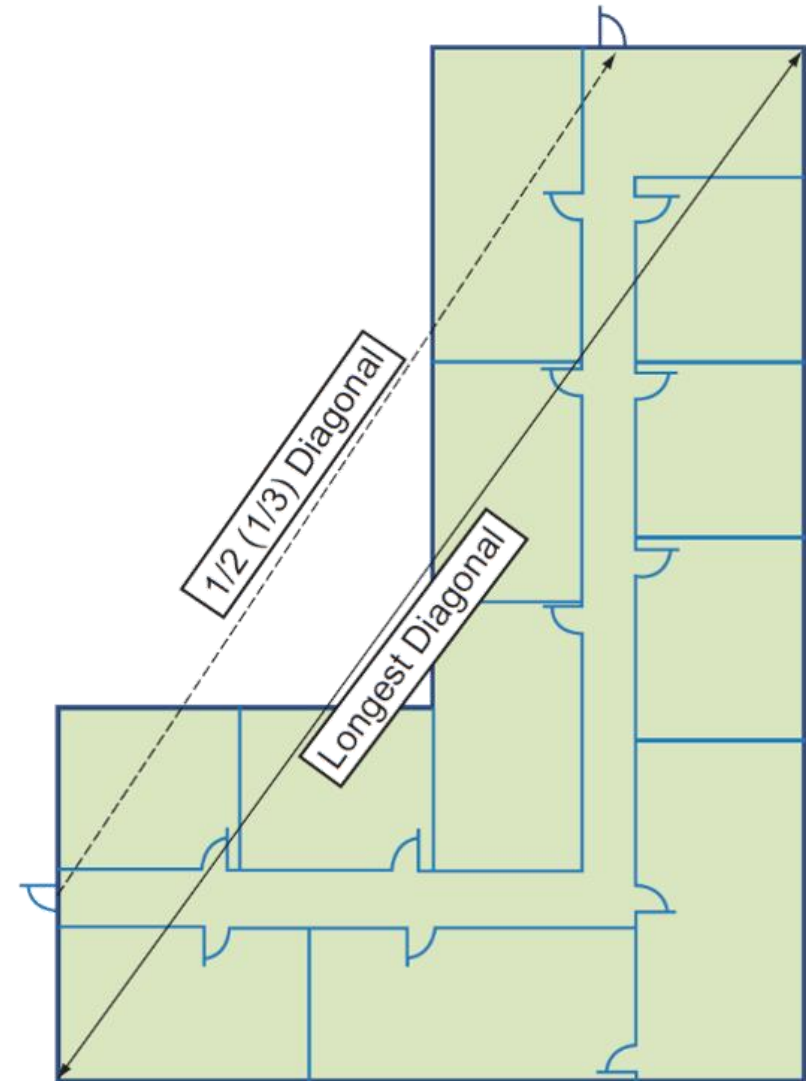
# Horizontal Travel

When >2 exits required

- Separated by  $\frac{1}{2}$  longest diagonal

With sprinklers

- Separation reduced to  $\frac{1}{3}$

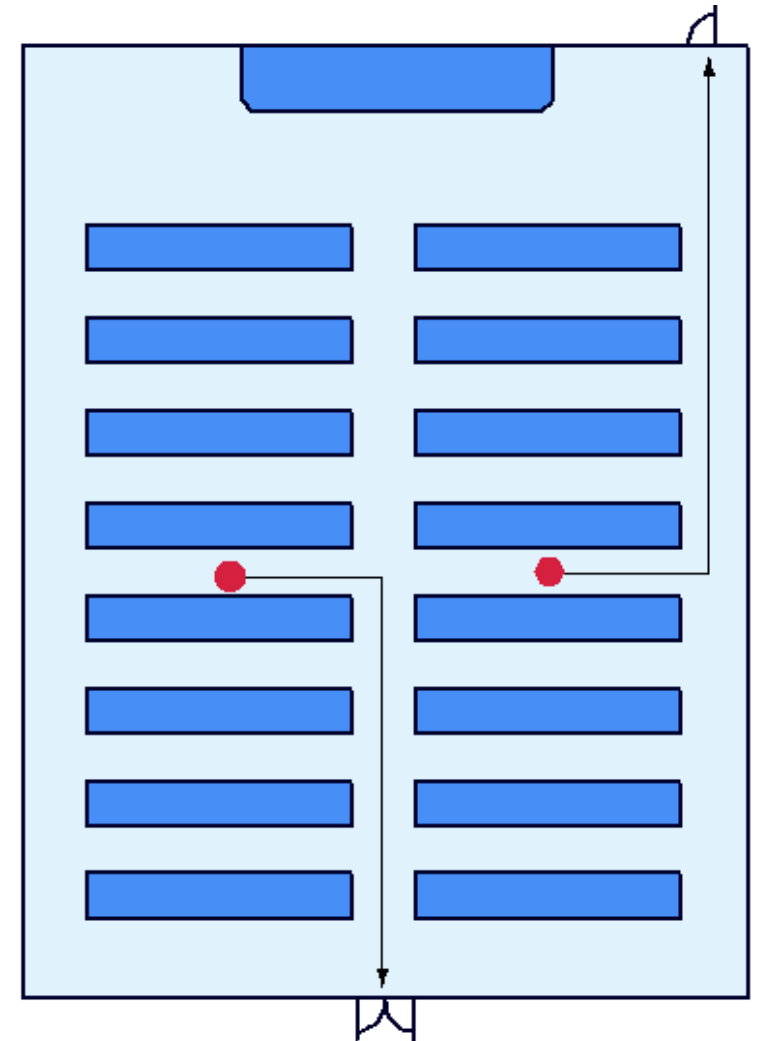


# Horizontal Travel

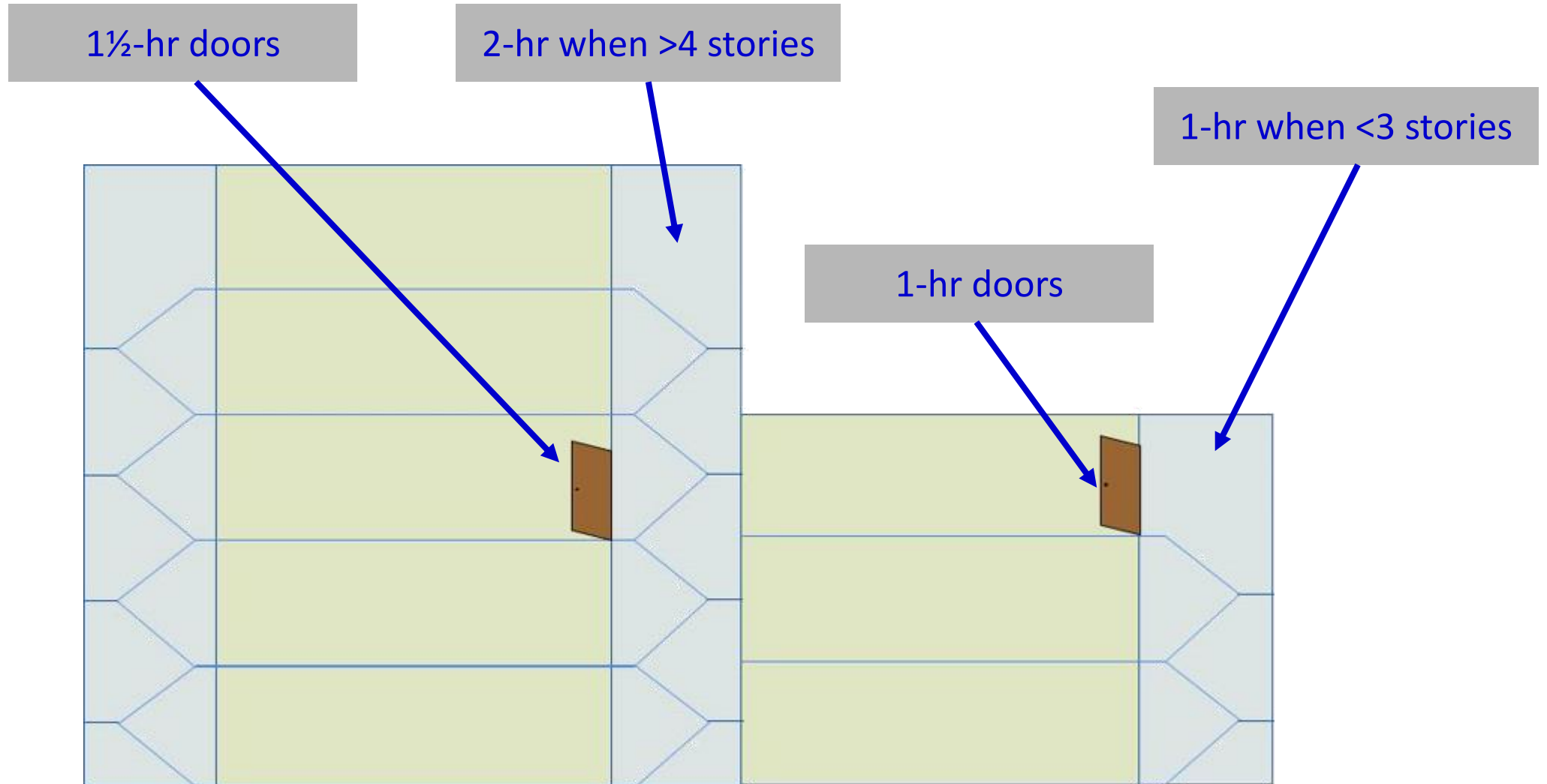
## Exit access travel distance

OCCUPANCY	WITHOUT SPRINKLER SYSTEM (feet)	WITH SPRINKLER SYSTEM (feet)
A, E, F-1, M, R, S-1	200	250
I-1	Not permitted	250
B	200	300
F-2, S-2, U	300	400
H-1	Not permitted	75
H-2	Not permitted	100
H-3	Not permitted	150
H-4	Not permitted	175
H-5	Not permitted	200
I-2, I-3	Not permitted	200
I-4	150	200

[Ref. Table 1017.2]



# Vertical Travel



# Exit Access Stairs and Ramps

- Open stairways and ramps used as part of MOE
- Travel distance measured to an exit
- Limited use





# Egress Path Identification

Exit signs required if >2 exits

- Additional floor-level exit signs in R-1
- Illuminated from internal or external light source

Egress path must be illuminated

- Emergency lighting required if > 2 exits

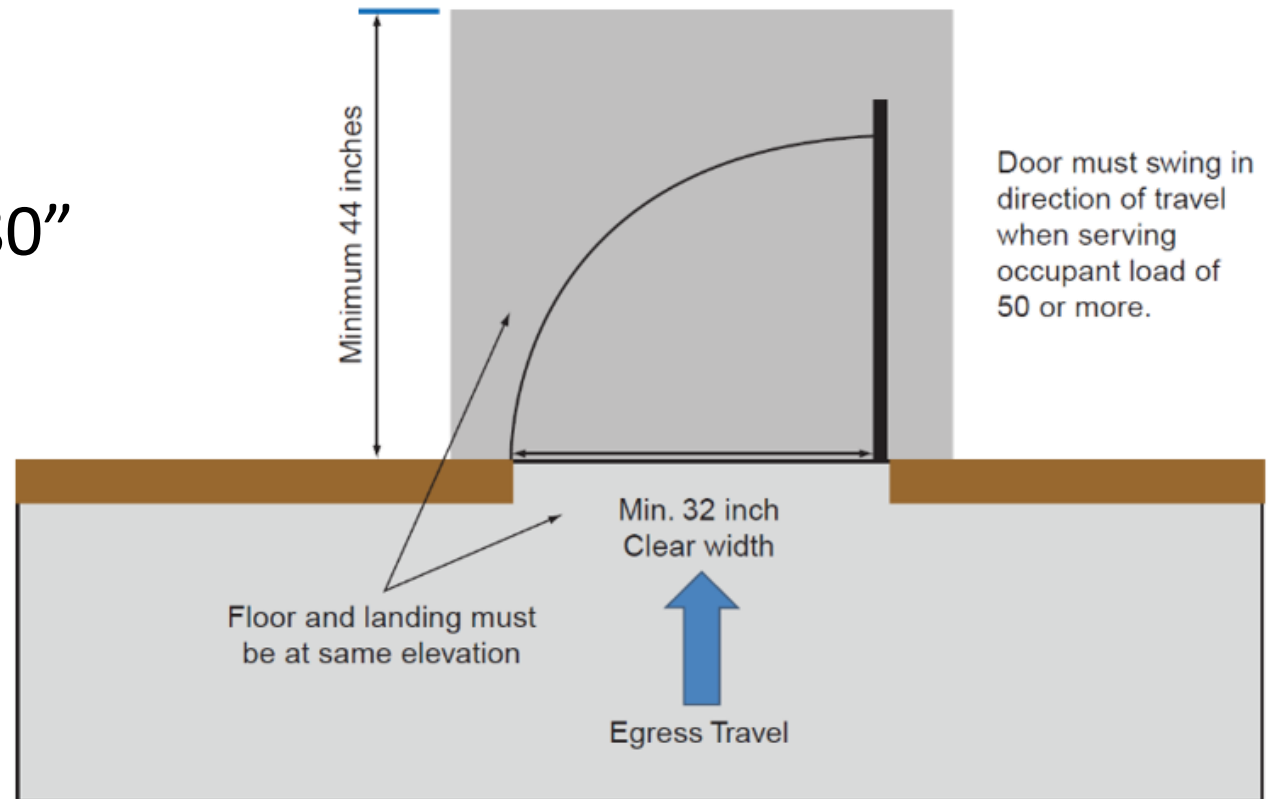


# Doors

All egress doors must be side-hinged swinging

- Some exceptions

Minimum clear height >80"



# Door Hardware

- Readily openable without a key or special knowledge or effort
- Forces required consistent with accessibility standards



# Panic Hardware

Required on doors in

- Group H
- Group A & E >50 occupants

*Fire exit hardware* = panic hardware  
listed for fire door assemblies

## Installation

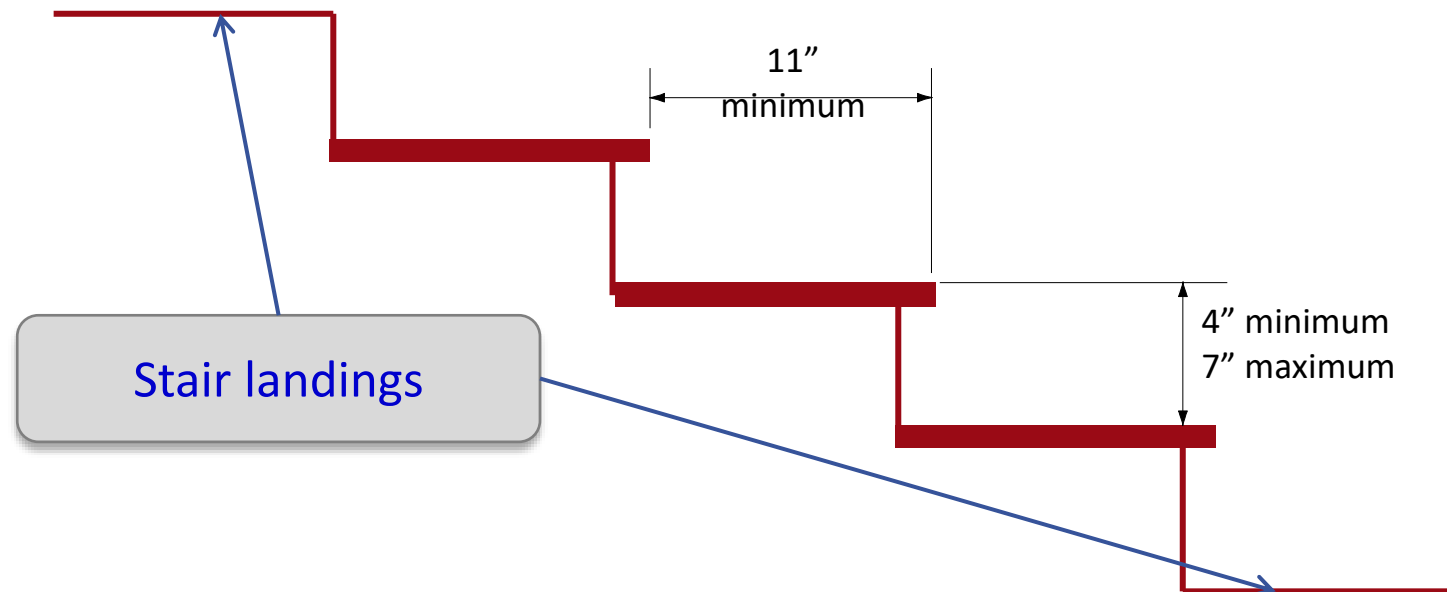
- Fire exit hardware
  - UL 10C and UL 305
- Panic Hardware
  - UL 305



# Stairways

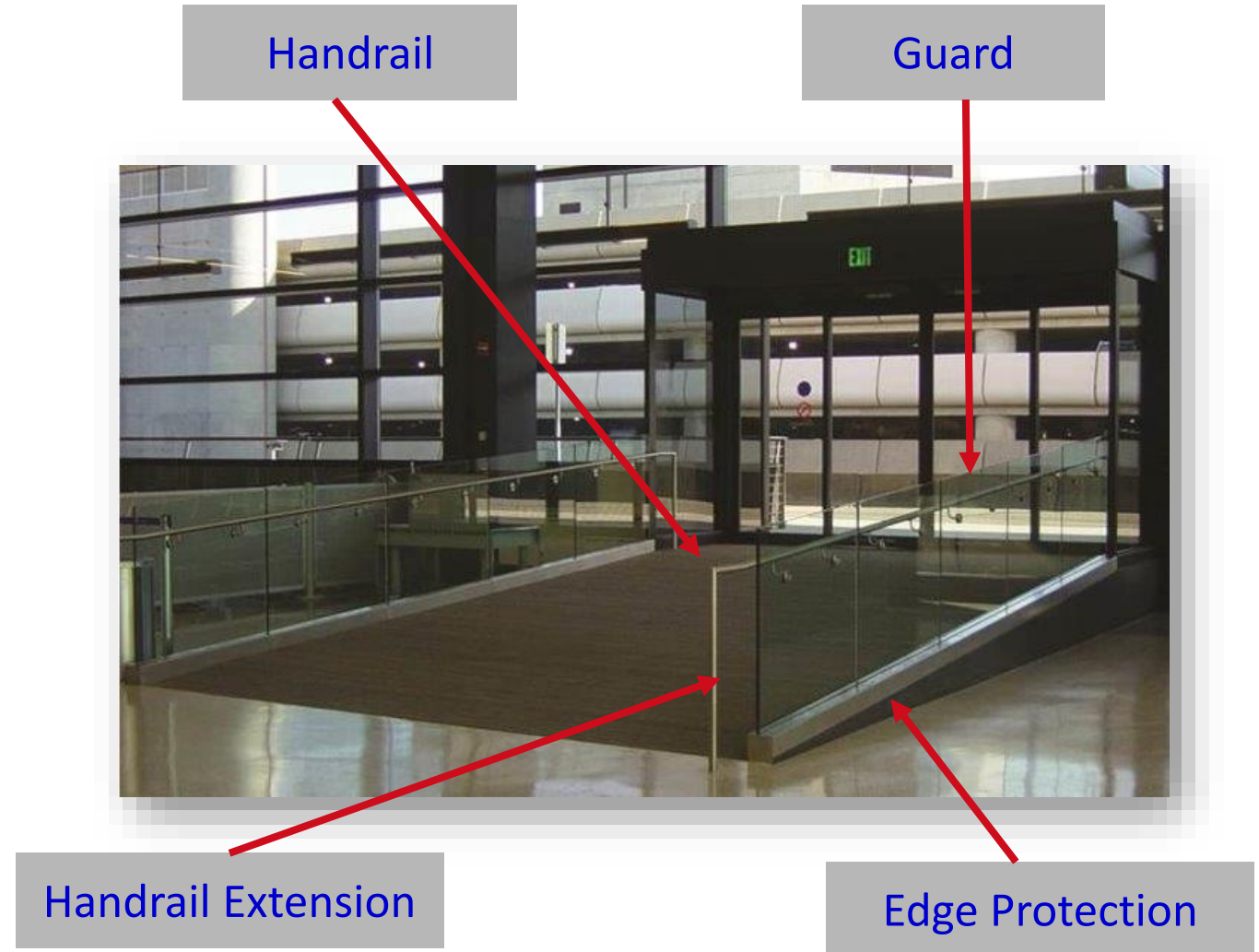
## Minimum width

- 36" for < 50 OL
- 44" for > 50 OL
- 0.3" x OL for > 146 OL
- With sprinklers and EV/AC
  - 0.2" x OL for > 220 OL



# Ramps

- Slopes < 1:12
- Ramps not part of MOE < 1:8
- Width
  - 36" minimum
  - 0.2" x OL
  - 0.15" x OL
    - With sprinklers and EV/AC





# Accessibility

IBC requirements similar to

- ADA Accessibility Guidelines
- Federal Fair Housing Act

Referenced standard

- ICC A117.1 – Accessible and Usable Buildings and Facilities

Areas not requiring accessibility

- Construction sites
- Detached 1- & 2-family dwellings
- Spaces containing equipment
- Coolers and freezers





# Accessible Path Into a Building

Accessible path from points where people arrive

- Public transportation stops
- Parking spaces
- Passenger loading zones
- Public streets or sidewalks

60% of public entrances must be accessible



# Accessible Path Through a Building

- Accessible route throughout from accessible entrance
- Route to other floors
  - Ramps
    - Slope < 1:12
  - Elevators
    - Cars sufficient for wheelchair and one extra person
    - Controls reachable from a wheelchair



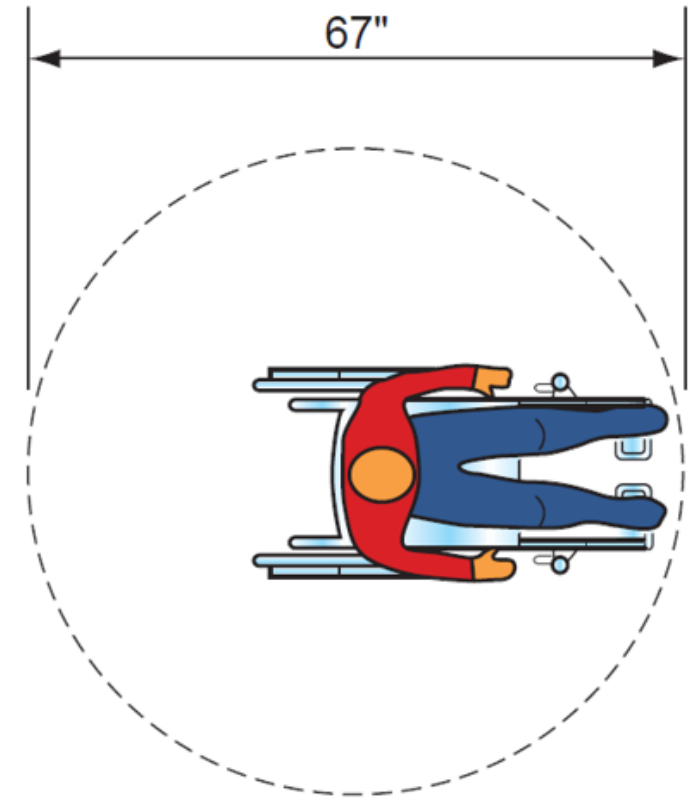
# Accessible Toilet Facilities

## Toilet rooms

- All accessible
- Family or assisted-use toilet room in Groups A and M

## Water closets

- >1 water closet wheelchair accessible

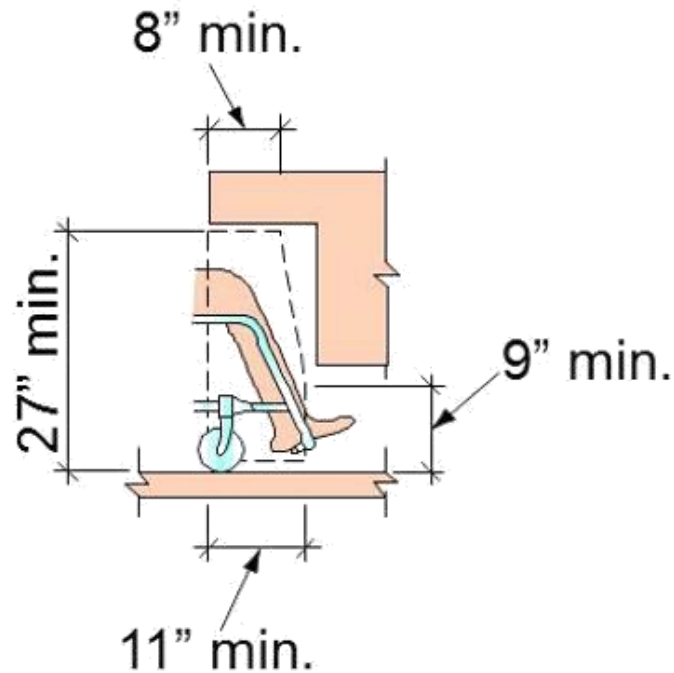


Circular Turning Space  
(New Buildings)

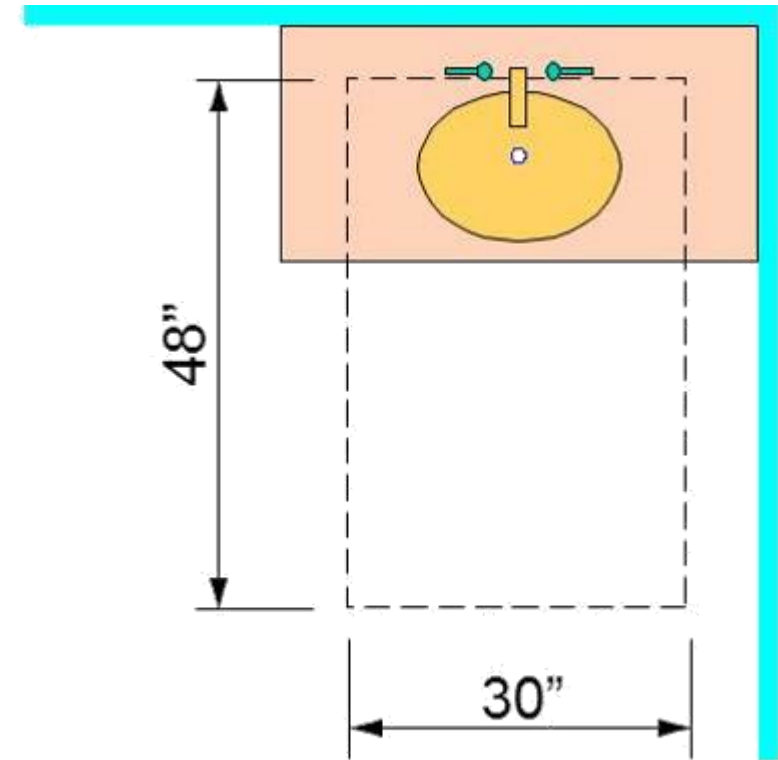
# Accessible Lavatories and Sinks

>5% of lavatories accessible

- >1 in each toilet facility



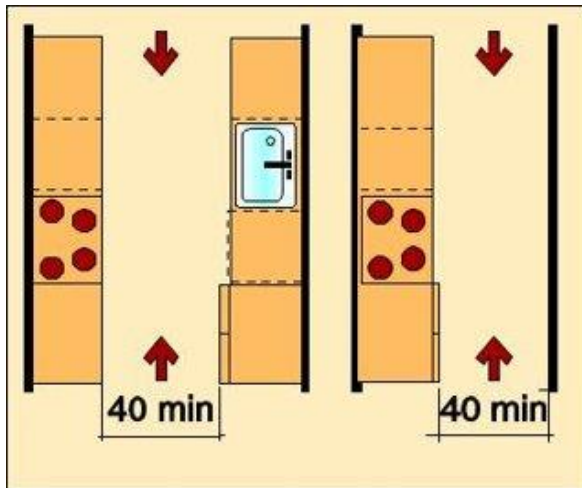
Knee and Toe Clearance



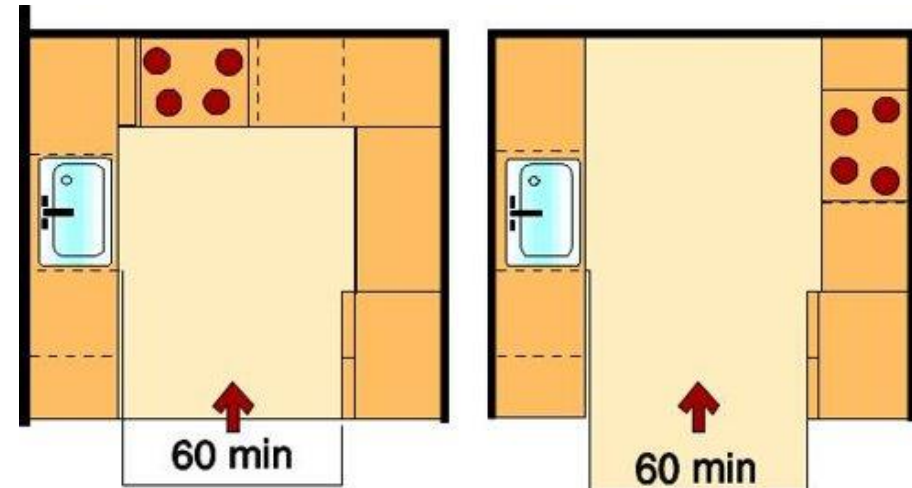
Clear Floor Space at Lavatory

# Accessible Kitchens

- Commercial kitchen route
  - Approach, enter and exit
- In break room type areas throughout



Pass -Through Kitchens



U-Shaped Kitchens

# Accessible Seating Areas

## Dining

- Total area for seating, interior/exterior, with some exceptions
- 5% dining surfaces

## Other than dining

- Dispersed throughout



CAPACITY OF SEATING IN ASSEMBLY AREAS	MINIMUM REQUIRED NUMBER OF WHEELCHAIR SPACES
4–25	1
26–50	2
51–100	4
101–300	5
301–500	6
501–5,000	6, plus 1 for each 150, or fraction thereof, between 501 through 5,000
5,001 and over	36 plus 1 for each 200, or fraction thereof, over 5,000

[Ref. IBC Table 1109.2.2.1]



# R-1 Accessible Dwelling/Sleeping Units

TOTAL NUMBER OF UNITS PROVIDED	MINIMUM REQUIRED NUMBER OF ACCESSIBLE UNITS WITHOUT ROLL-IN SHOWERS	MINIMUM REQUIRED NUMBER OF ACCESSIBLE UNITS WITH ROLL-IN SHOWERS	TOTAL NUMBER OF REQUIRED ACCESSIBLE UNITS
1 to 25	1	0	1
26 to 50	2	0	2
51 to 75	3	1	4
76 to 100	4	1	5
101 to 150	5	2	7
151 to 200	6	2	8
201 to 300	7	3	10

[Ref. Table 1108.6.1.1]



# Accessible Means of Egress

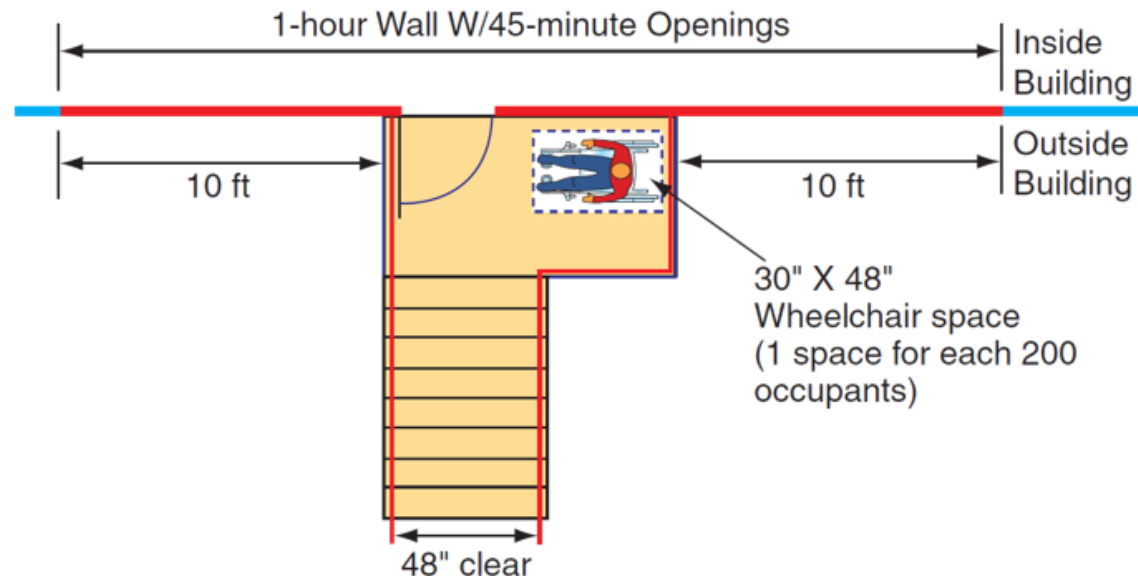
Non Sprinklered buildings requiring

- One exit needs 1 accessible MOE
- > 2 exits needs 2 accessible MOE

>4 stories

- Elevator as 1 accessible MOE

Accessible MOE must continue to public way or Area of Assisted Rescue



# Accessible Areas of Refuge

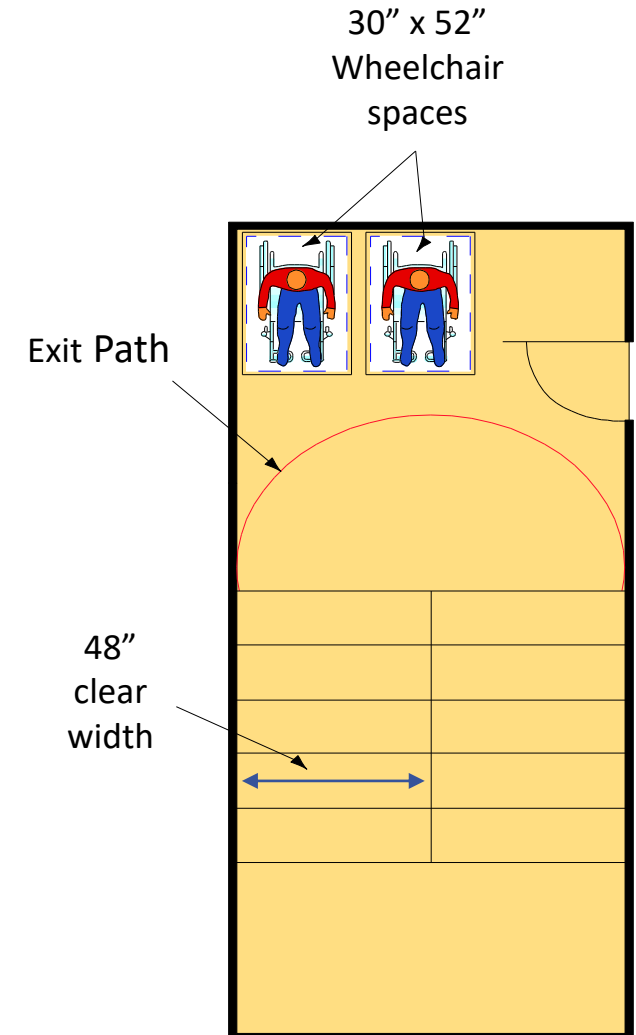
One wheelchair space for every 200 occupants

- Not required in sprinklered buildings

Location

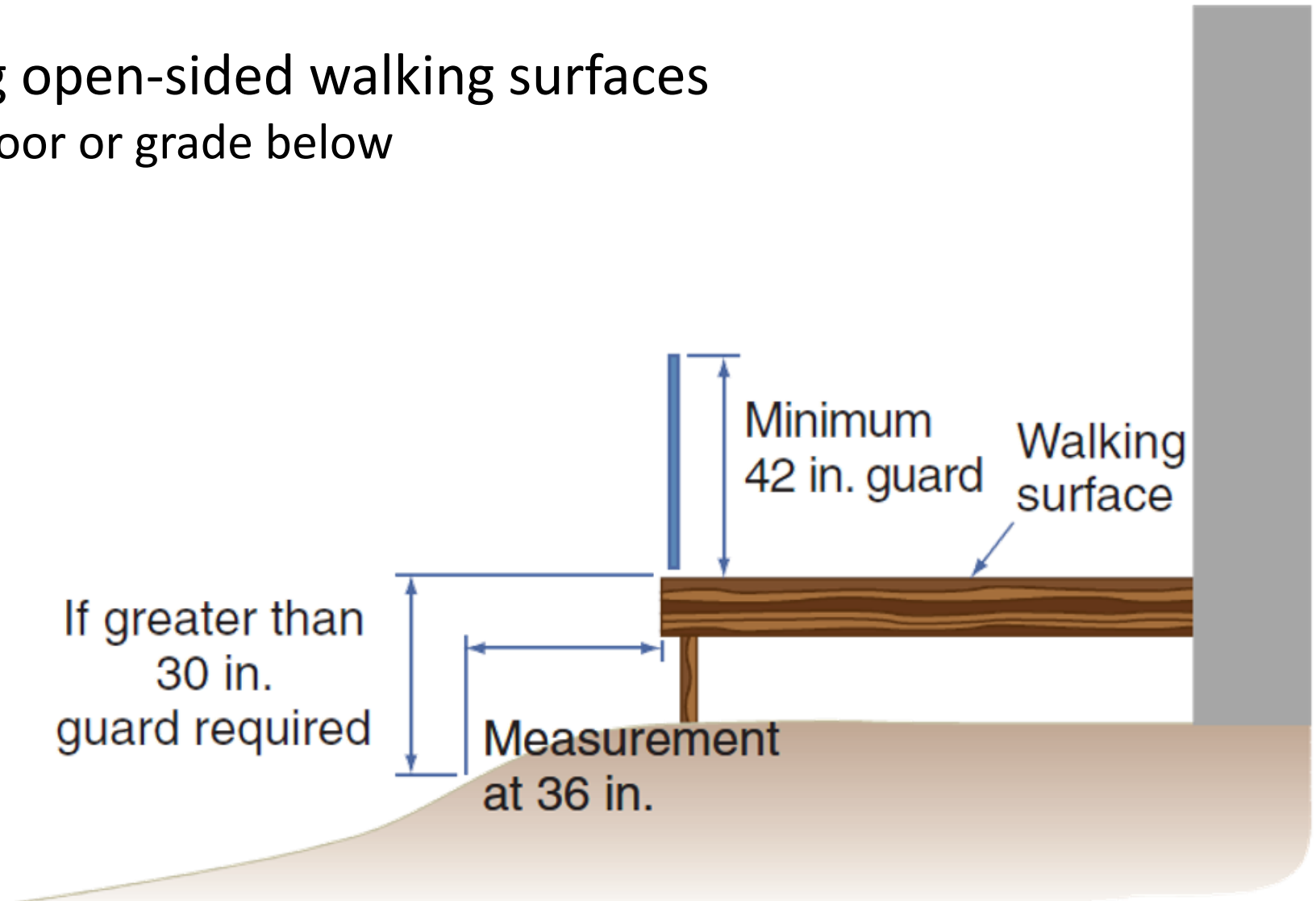
- Stairway enclosure
- Elevator lobby

2-way communication required



# Guards

- Required along open-sided walking surfaces
  - >30" above floor or grade below



# Stairway Guards and Handrails

Guard – system of posts, handrails and balusters/panels

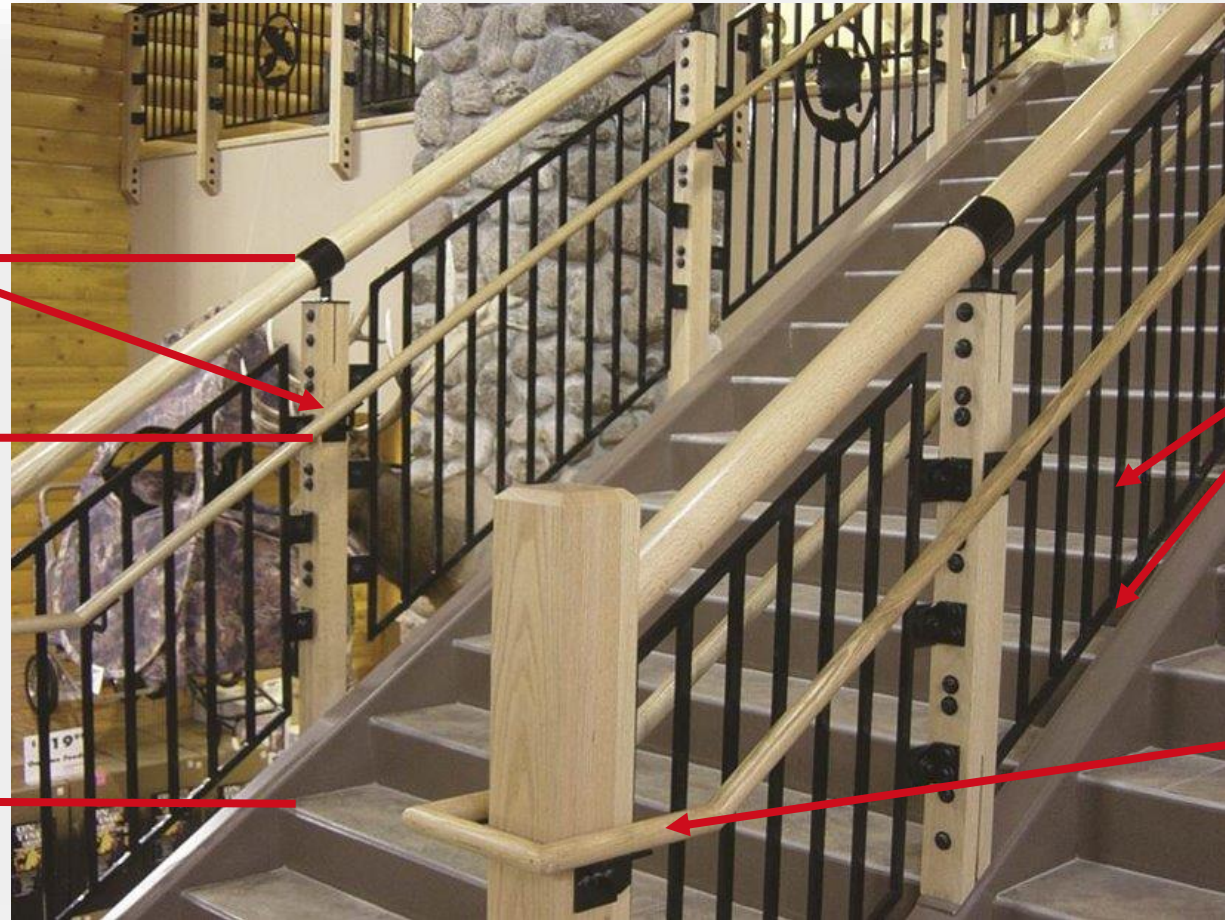
Handrail

42" minimum

34" to 38"

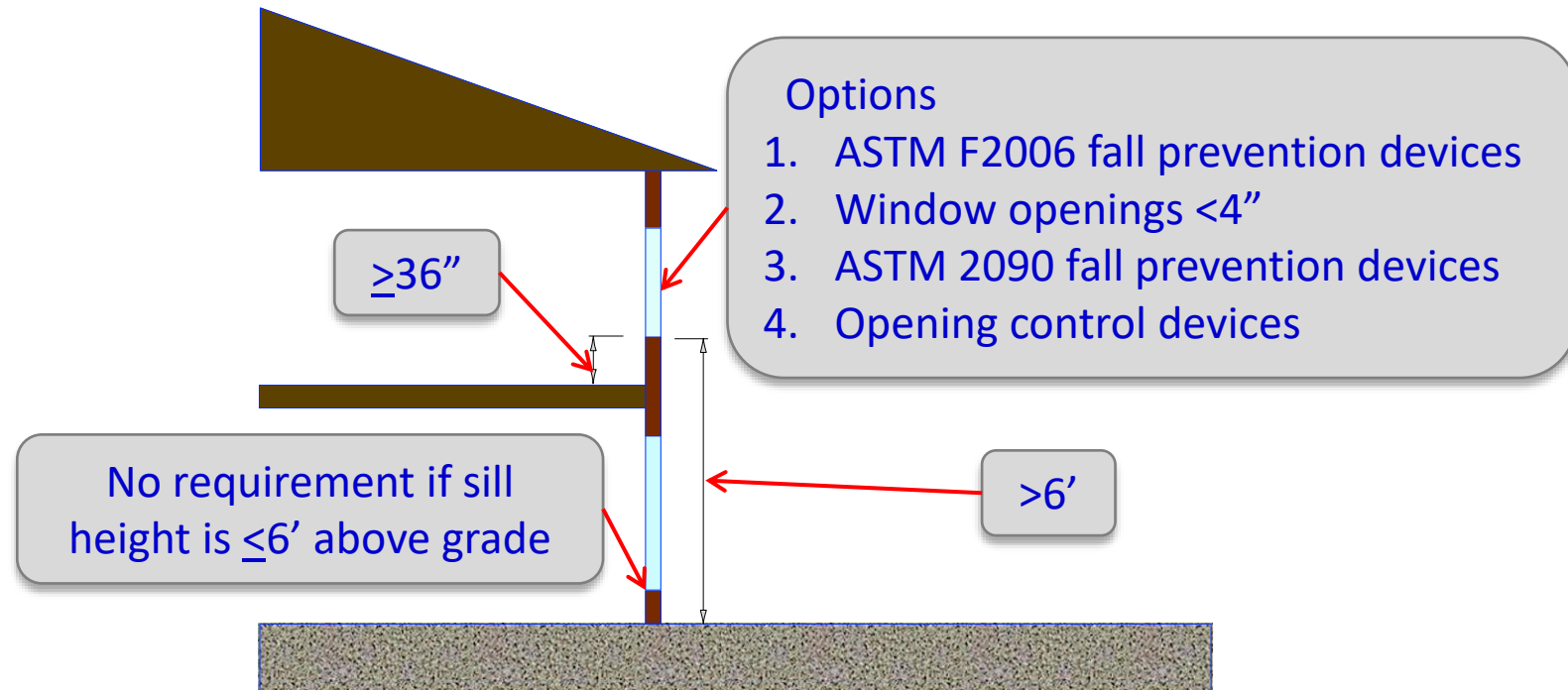
Openings <4"

Handrail extension



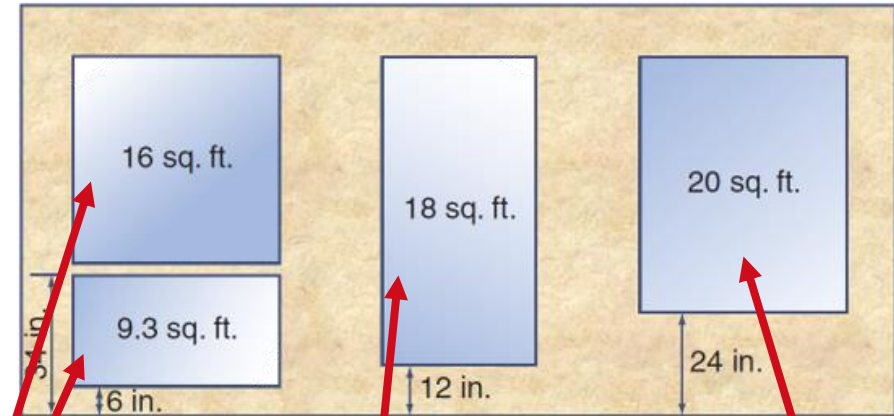
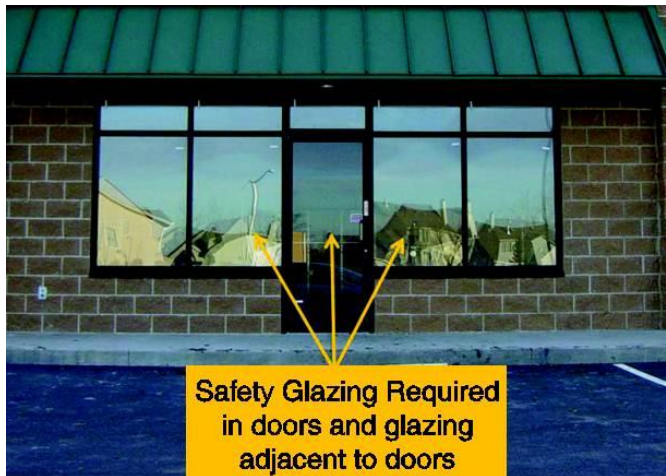
# Window-sill Height

Regulated in R-2 and R-3 residential



# Safety Glazing

- Laminated glass
- Tempered glass
- Must be labeled
- Required locations
  - Doors
  - Within 24" of doors
  - Along walking areas with size thresholds



Safety  
glazing  
required

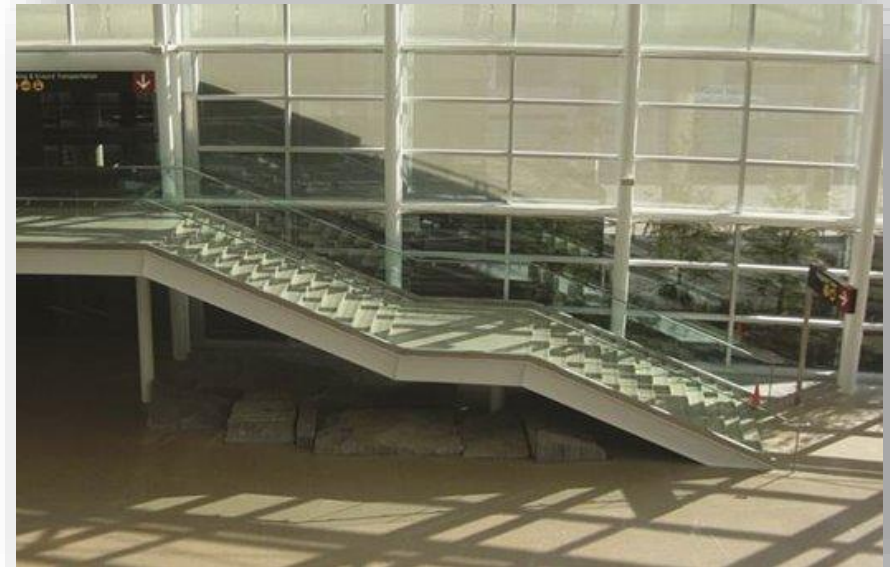
Not required  
Top of bottom panel <36 in. AFF  
Bottom of top panel >18 in. AFF

Not required  
Bottom panel >18 in. AFF



# Safety Glazing

- Tub or shower enclosures
- <60" of pool or spa
- Stairway guard or railing
- <36" of stairway or landing
- <60" of walking surface





# Swimming Pools

## International Swimming Pool and Spa Code

- Any structure intended for swimming
- Water depth > 24"
- In-ground, above-ground and on-ground pools
- Hot tubs and spas
- Fixed-in-place wading pools



# Poll Question

16. In a Group A-2 restaurant with tables and chairs, the occupant load is determined based on a factor of \_\_\_\_\_ per person.

- a. 5 net
- b. 7 net
- c. 15 net
- d. 150 gross



# Poll Question

17. In a Group A-2 restaurant, 2 exit doors are required when the occupant load is \_\_\_\_\_ or more.
- a. 11
  - b. 21
  - c. 30
  - d. 50



# Poll Question

18. In a non-sprinklered Group B office building with an occupant load of 95, the common path of egress travel is limited to \_\_\_\_\_ feet.
- a. 25
  - b. 75
  - c. 100
  - d. NP



# Poll Question

19. Exit access travel distance is limited to \_\_\_\_\_ feet in a Group M occupancy equipped with a fire sprinkler system.
- a. 75
  - b. 200
  - c. 250
  - d. 300



# Poll Question

20. Doors must swing in the direction of egress when the occupant load is \_\_\_\_\_ or more.

- a. 25
- b. 50
- c. 75
- d. 100



# Poll Question

21. In buildings with more than 1 required means of egress, at least \_\_\_\_\_ of the means of egress must be accessible.

- a. 1
- b. 2
- c. 3
- d. All





# Discussion



# Health Safety

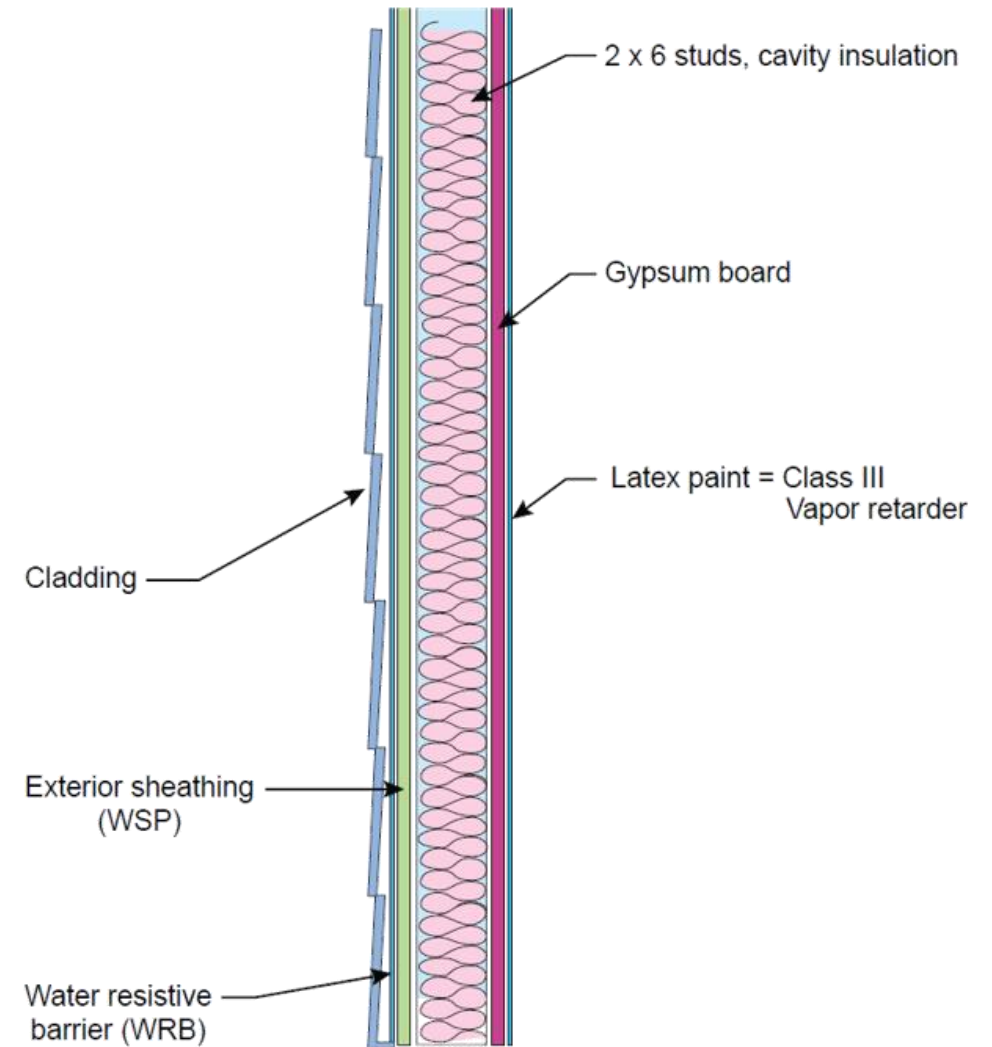


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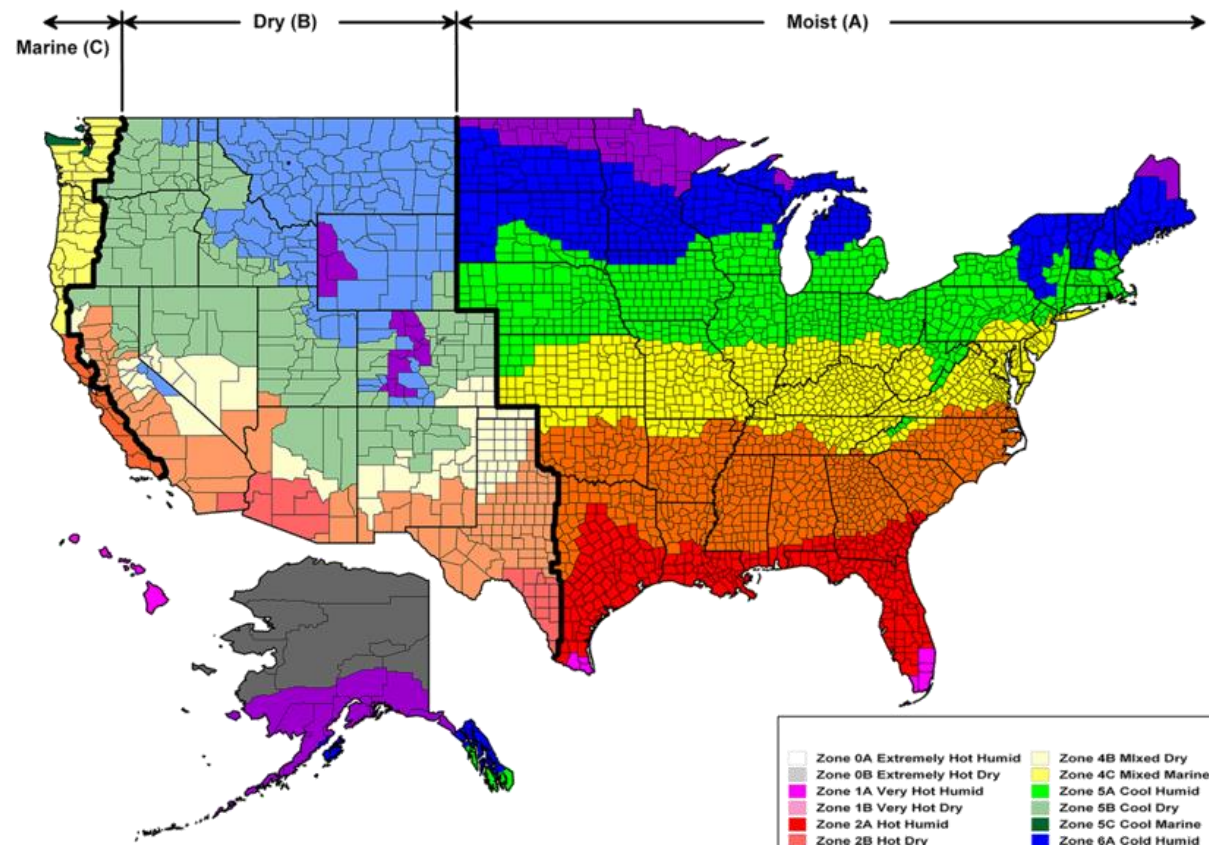
# Keeping Water Out

## Weather-resistant exterior wall envelope

- Water-resistive barrier (WRB)
- Flashing



# Vapor Retarders



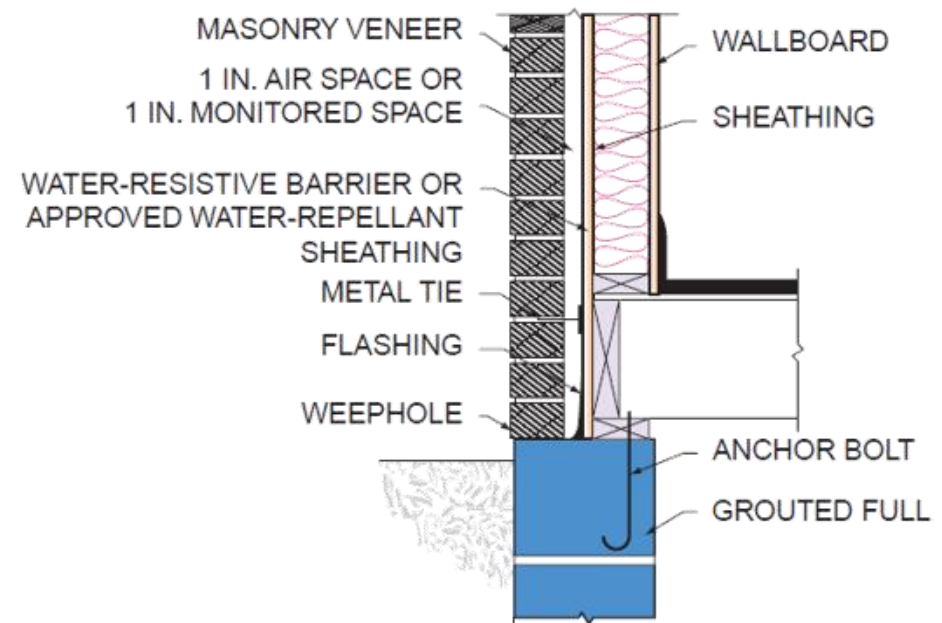
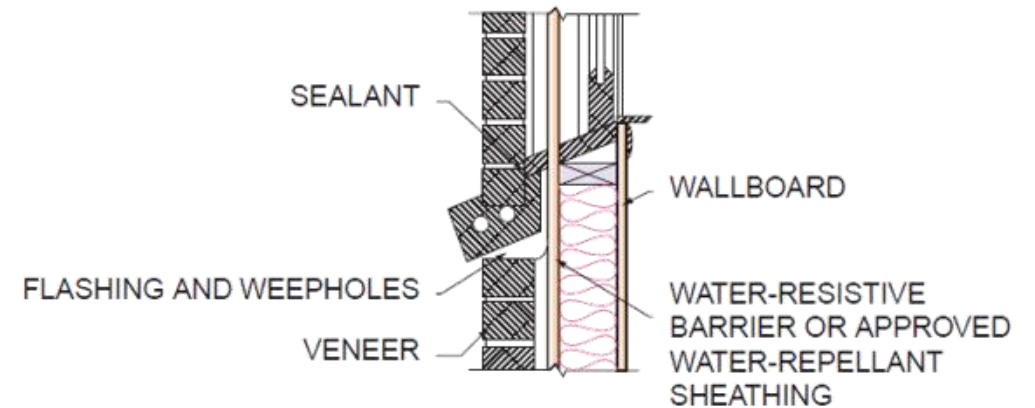
CLIMATE ZONE	VAPOR RETARDER CLASS		
	I	II	III <sup>a</sup>
1, 2	Not permitted	Not permitted	Permitted
3	Not permitted	Permitted	Permitted
4 (except Marine)	Not permitted	Permitted	See Table 1404.3(3)
Marine 4, 5, 6, 7, 8	Permitted	Permitted	See Table 1404.3(3)

[Ref. Table 1404.3(2)]

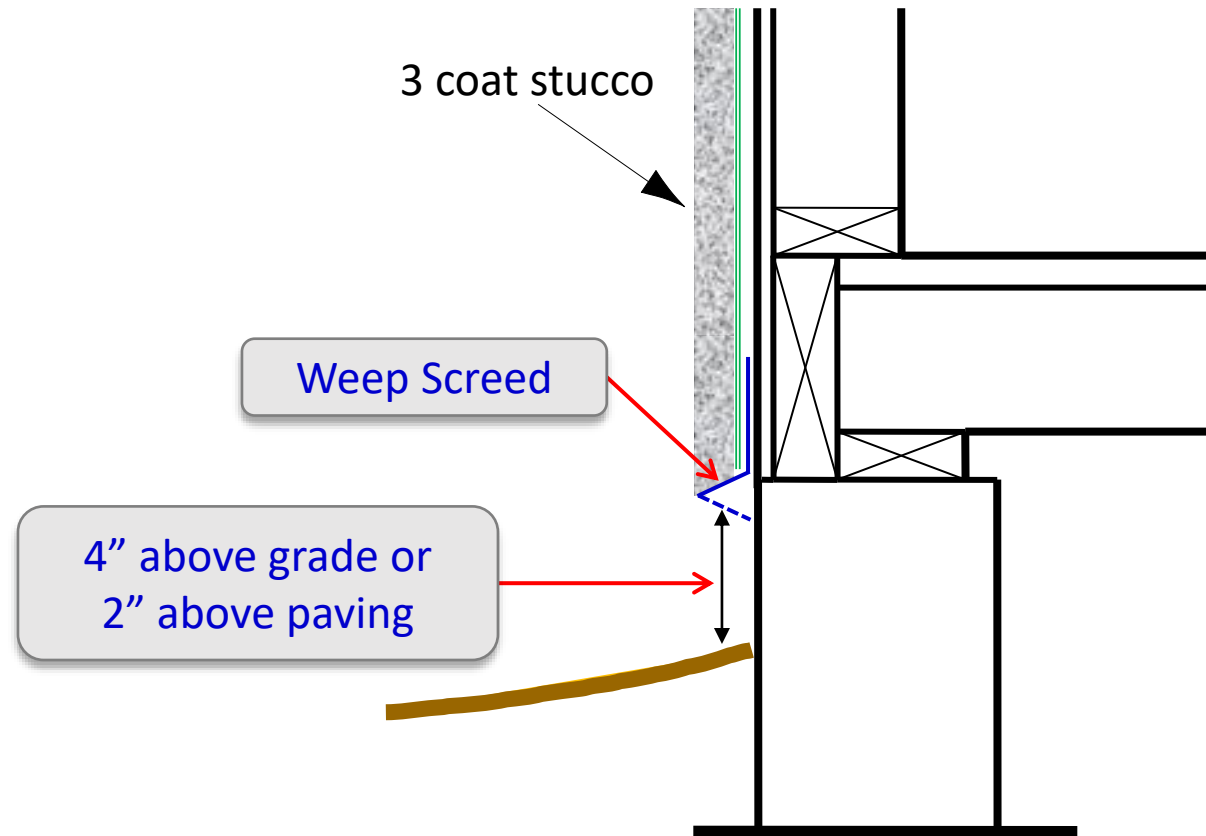
# Siding

Many materials available

IBC Table 1404.2 specifies  
minimum thickness



# Siding



# Roofing

- Roof coverings must meet
  - Chapter 15
  - Manufacturer's instructions
  - Code prevails if conflicts arise
- Minimum slope dependent on roof covering chosen
- Roof drains or scuppers required if water cannot drain off roof edge





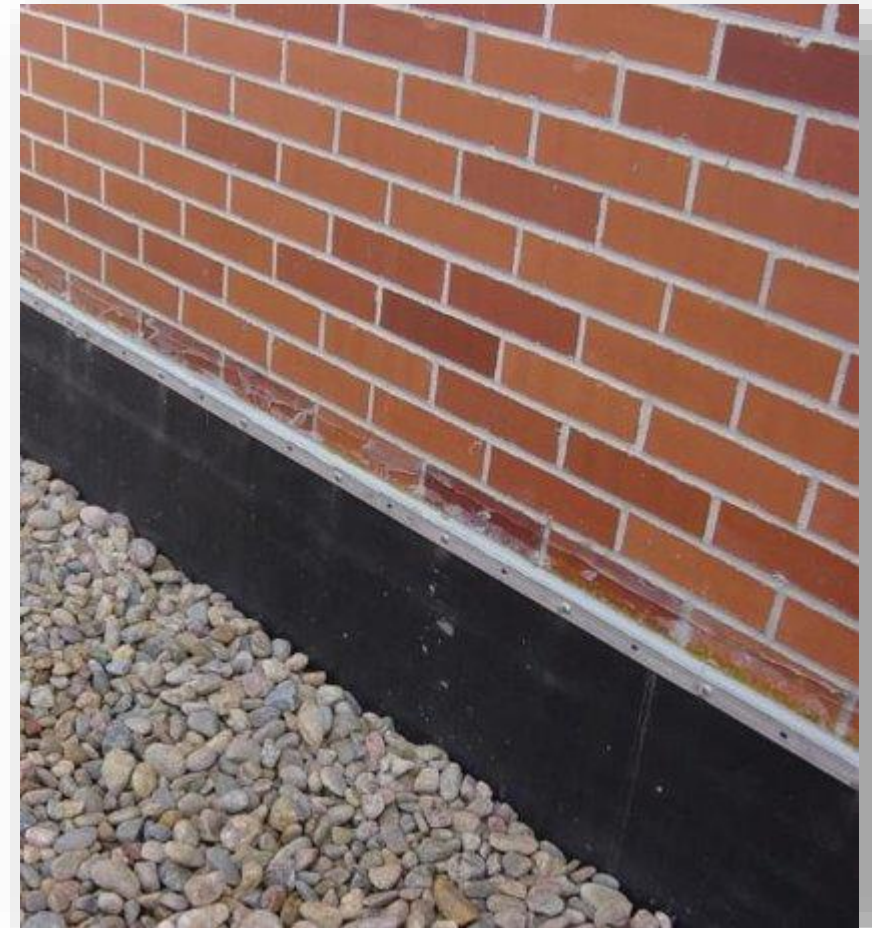
# Flashing

Installed at

- Wall and roof intersections
- Gutters
- Change in roof slope or direction
- Around roof openings

Parapets coped with weatherproof materials

- FRR parapet coping materials
- Weatherproof
- Maintain required FRR



# Low-slope Roofs

Slope can be as low as ¼:12

## Roof covering systems

- Built-up
  - Asphalt
  - Coal tar pitch
- Modified bitumen
- Thermoset single-ply roof covering (EPDM)
- Thermoplastic single-ply roof covering (PVC, TPO, CSPE)

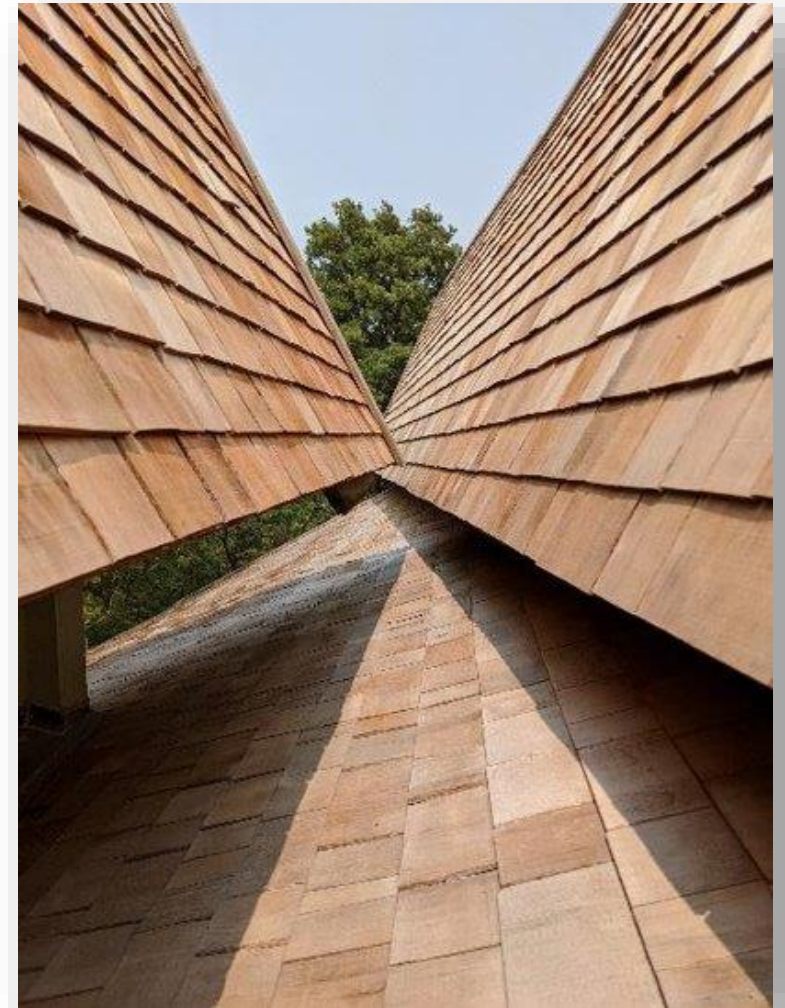


# Steep Roofs

Slopes > 3:12

## Common roof covering materials

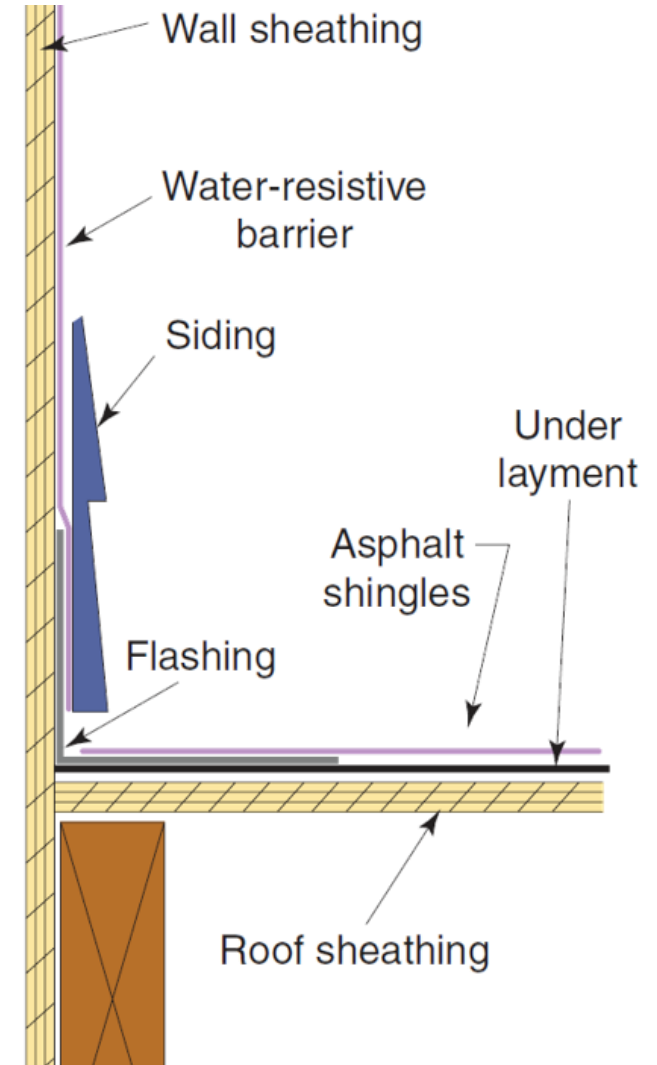
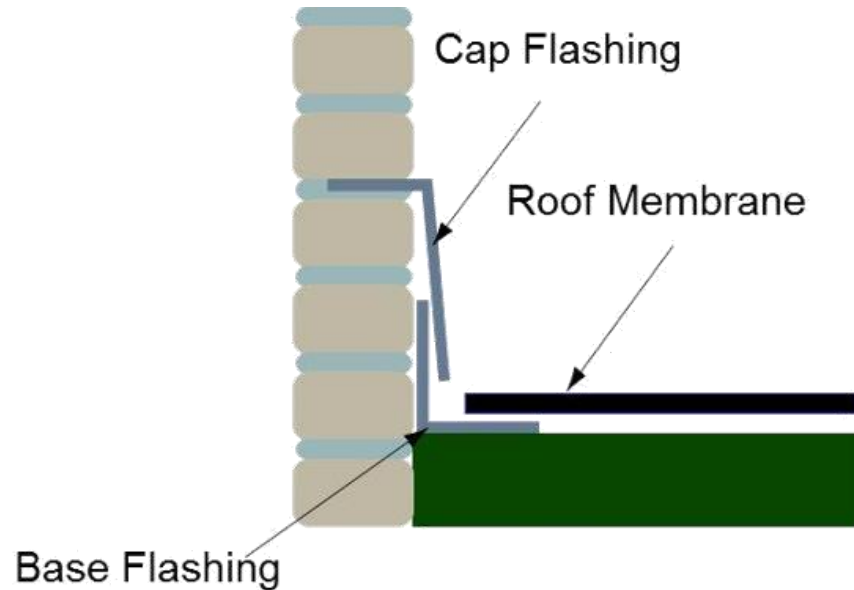
- Asphalt shingles
- Wood shakes
- Wood shingles
- Clay tiles
- Concrete tiles
- Metal roof panels



# Flashing

## Required at

- Roof and wall intersections
- Valleys
- Drip edge





# Clay and Concrete Tiles

Installed over solid sheathing or spaced sheathing

Minimum slope of 2½:12

- Double underlayment <4:12
- Single underlayment >4:12



Flashing

Bird Stop

# Light and Ventilation

## Lighting

- Natural
- Artificial

## Ventilation

- Natural
- Mechanical
  - Installed per IMC
- Ventilation of attics and crawl spaces also required



# Natural and Artificial Lighting

## Natural lighting

- Openings/windows in exterior walls that allow sunshine in

## Artificial lighting

- Electrical-powered

## If natural light inadequate

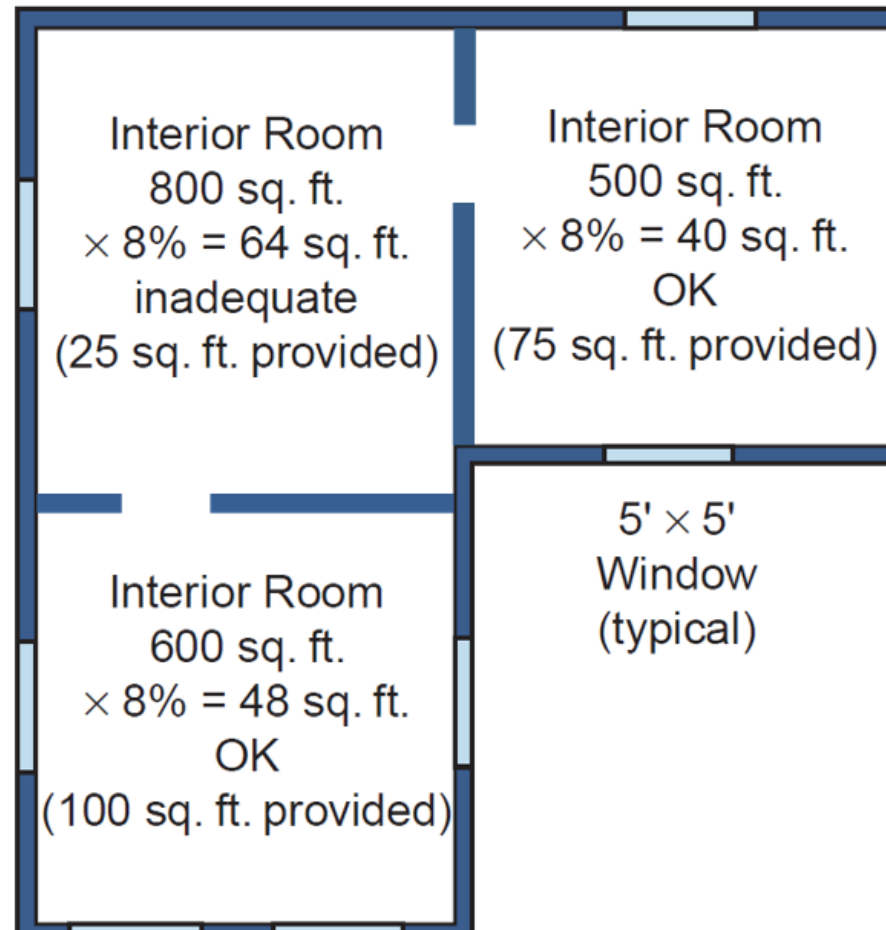
- Artificial light installed
- Must provide >10 foot-candles at 30" height





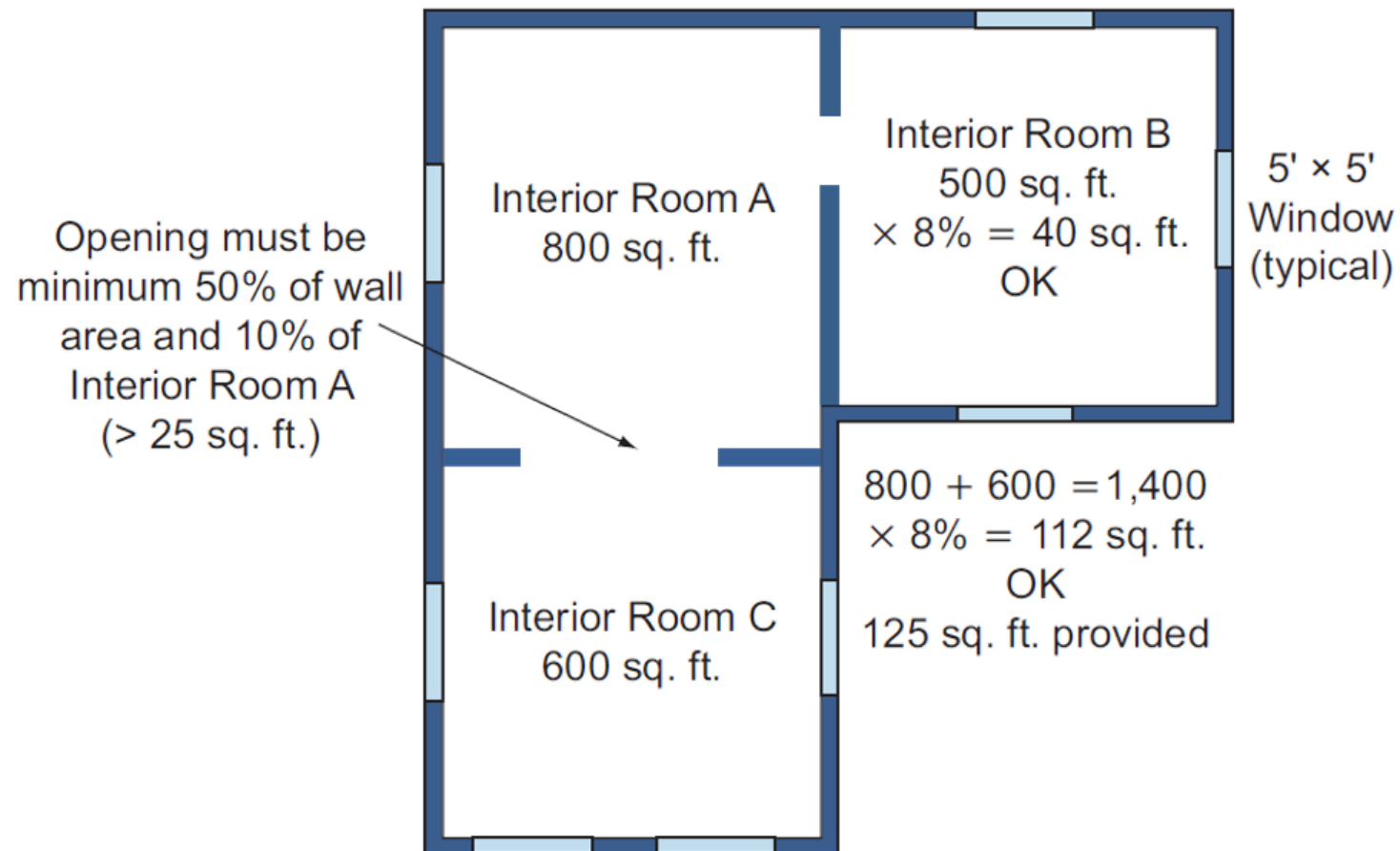
# Natural Lighting

Openings  $>8\%$  of floor area



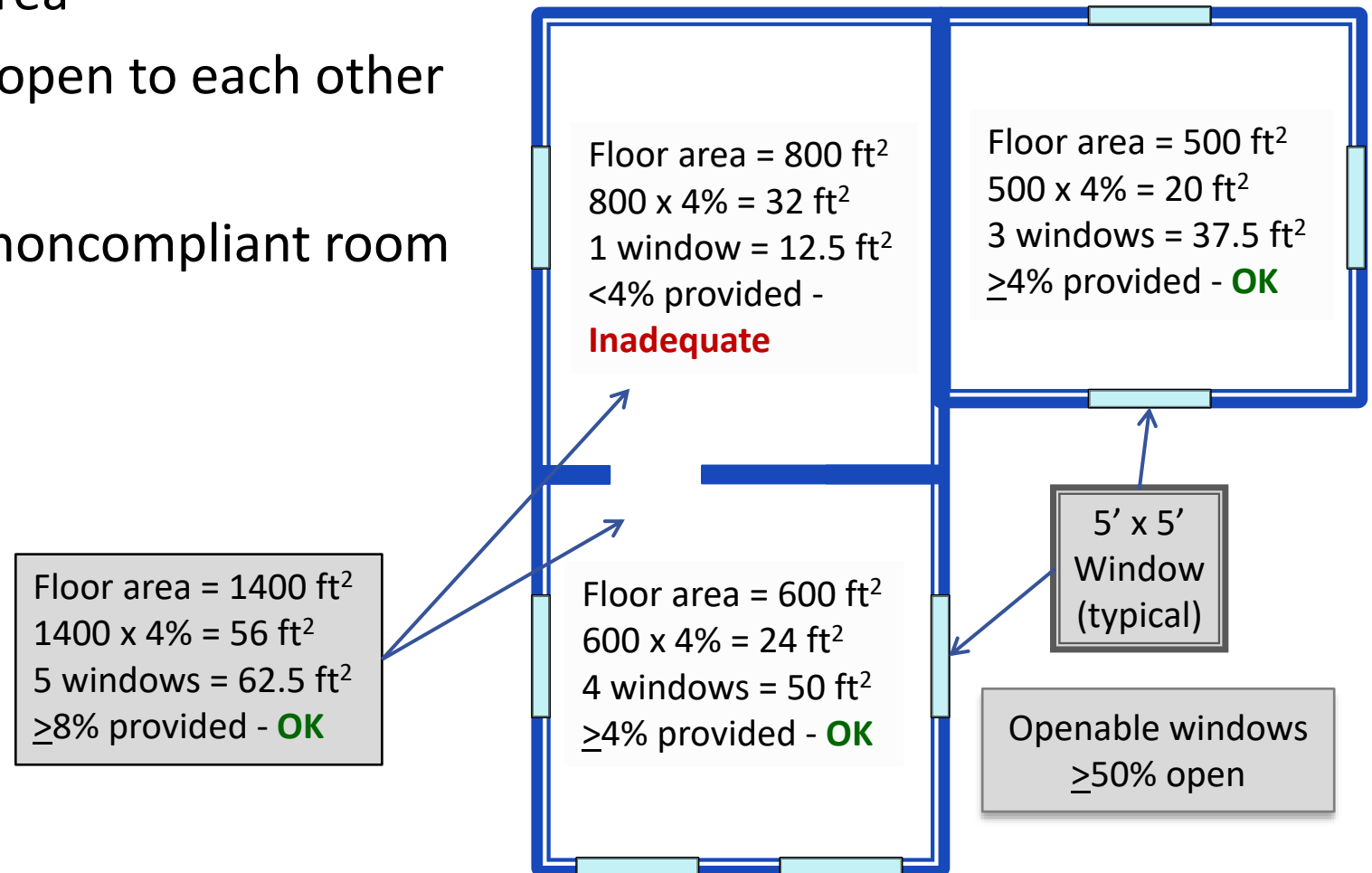
# Natural Lighting

Rooms combined when open to each other



# Natural Ventilation

- Openings  $\geq 4\%$  of floor area
- Rooms combined when open to each other
- Opening must be
  - $\geq 8\%$  of floor area of noncompliant room
  - $\geq 25 \text{ ft}^2$



# Exhaust Systems

Moisture created inside buildings removed

- Bathrooms with bathtubs, spas, etc.

Contaminants removed

- Contaminants in naturally ventilated spaces
- Flammable and combustible hazards
- Per IMC and IFC



# Temperature

## Interior space for human occupancy

- Requires heating system
  - Active or passive
- Min indoor temperature
  - 68°F at 3' above floor

## Design temperature

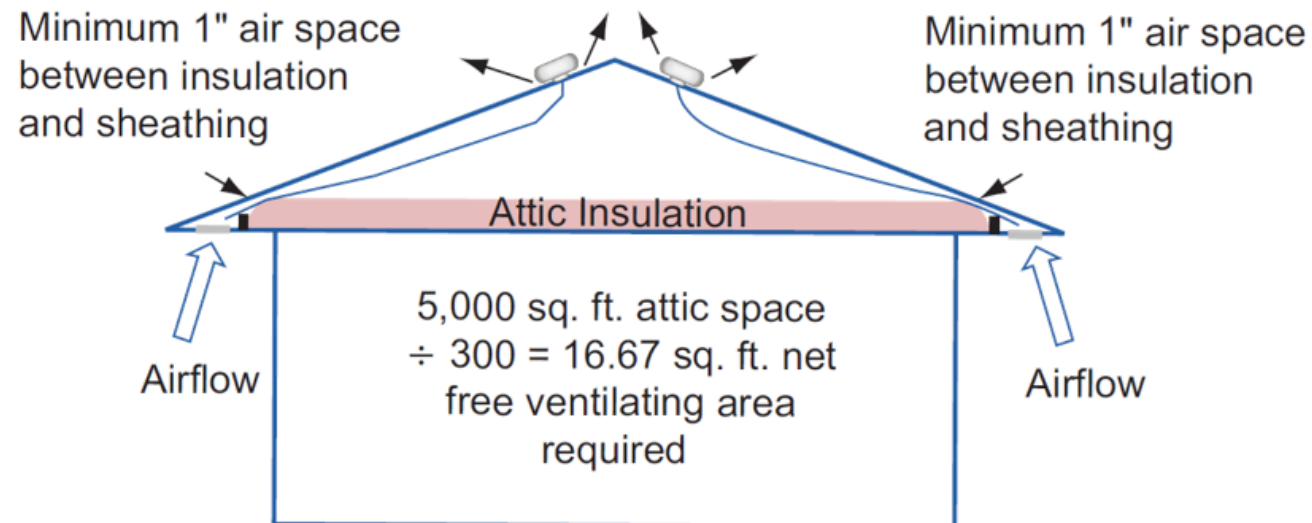
- Outdoor temperature
  - Used for design
- IPC Appendix D

LOCATION	WINTER DESIGN TEMPERATURE (degrees F)
Minneapolis, MN	-12
Chicago, IL (O'Hare)	-4
Buffalo, NY	6
Kansas City, MO	6
Dallas, TX	22
San Diego, CA	44

[Ref. IPC Table D101]

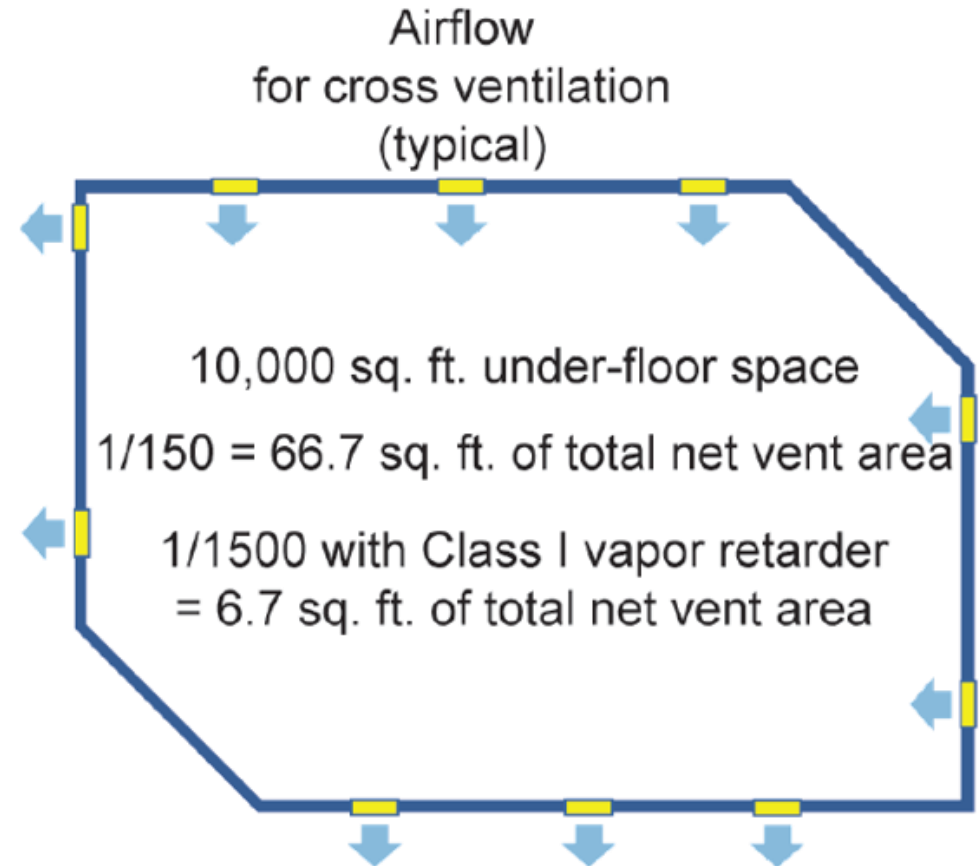
# Moisture Control in Attics

- Net free area of attic vents
  - $>1/150$  attic area
  - $>1/300$  when
    - 40–50% of openings in top 3' of attic
    - Remainder at eave or cornice vents
  - $>1/300$  with Class I or II vapor barrier



# Under-floor Ventilation

- Ratio of 1 ft<sup>2</sup> of opening for 150 ft<sup>2</sup> of under-floor space
- Class I vapor retarder
  - Ratio of 1 ft<sup>2</sup> of opening for 1,500 ft<sup>2</sup> of under-floor space



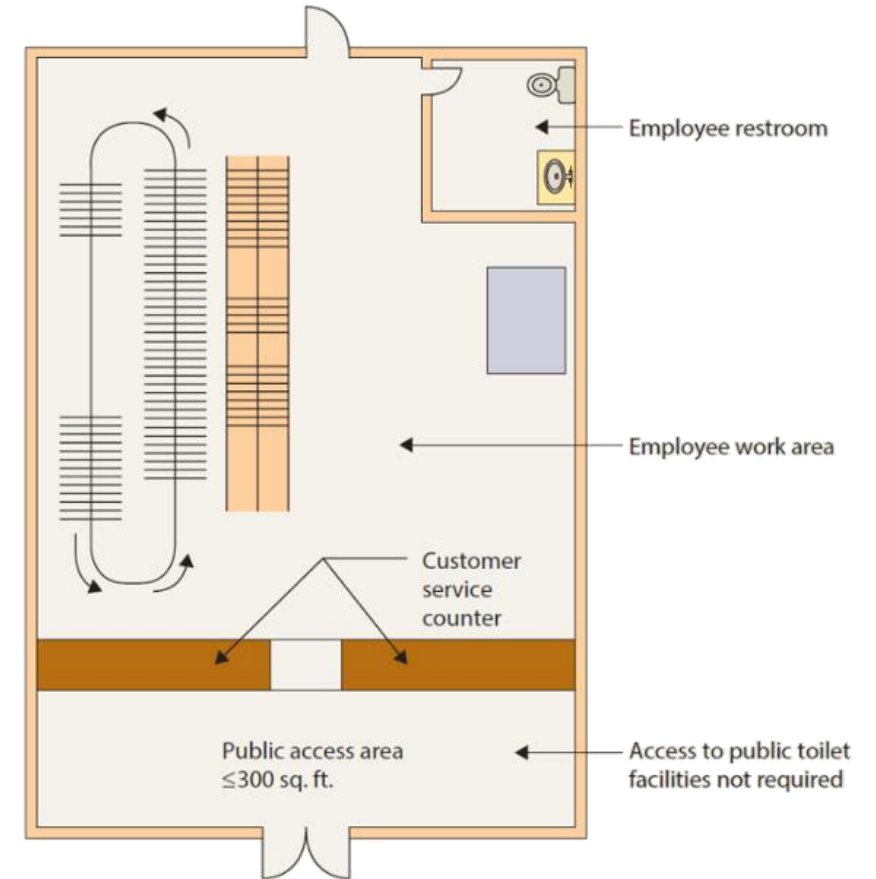


# Plumbing Facilities

Classification	Occupancy	Description	Water closets		Lavatories		Bathtubs/ showers	Drinking fountains*	Other
			Male	Female	Male	Female			
Assembly	A-2	Restaurant, banquet halls and food courts	1 per 75	1 per 75	1 per 200		–	1 per 500	1 service sink
	A-3	Auditoriums without permanent seating, art galleries, exhibition halls, museums, lecture halls, libraries, arcades and gymnasiums	1 per 125	1 per 65	1 per 200		–	1 per 500	1 service sink
Business	B	Buildings for the transaction of business, professional services	1 per 25 for the first 50 and 1 per 50 for the remainder exceeding 50		1 per 40 for the first 80 and 1 per 80 for the remainder exceeding 80		–	1 per 100	1 service sink
Educational	E	Educational facilities	1 per 50		1 per 50		–	1 per 100	1 service sink

# Location of Toilet Facilities

- Toilet facilities provided for
  - Employees
  - Public – if public building
- Public access
  - Accessible
  - Cannot pass through kitchens, storage rooms, or closets
- Distance <500'
  - Longer distances for factory, storage and industrial
  - Building official approval



# Toilet/Bathing Room Finishes



Minimum height  
of 4'

Smooth, hard,  
non-absorbent finish

Extends up wall  
>4"

Privacy partitions



# Poll Question

22. Buildings must be designed with a water-resistant barrier in the exterior wall envelope behind the exterior veneer.
- a. True
  - b. False



# Poll Question

23. Minimum roof slope must be

\_\_\_\_\_ :12

- a. 0
- b.  $\frac{1}{4}$
- c.  $2\frac{1}{2}$
- d. 3



# Poll Question

24. Either natural light or artificial light can be utilized to meet the minimum lighting requirements.
- a. True
  - b. False



# Poll Question

25. Attics and under-floor areas must be provided with ventilation at a ratio of 1 ft<sup>2</sup> of vent area for every \_\_\_\_\_ ft<sup>2</sup> of area.

- a. 150
- b. 300
- c. 500
- d. 1500





# Poll Question

26. A Group A-3 gymnasium with an occupant load of 625 requires \_\_\_\_\_ water closets for male use.

- a. 3
- b. 4
- c. 5
- d. 6



# Poll Question

27. Except in mall buildings, the maximum travel distance to a water closet cannot exceed \_\_\_\_\_ feet.
- a. 200
  - b. 300
  - c. 400
  - d. 500



# Discussion



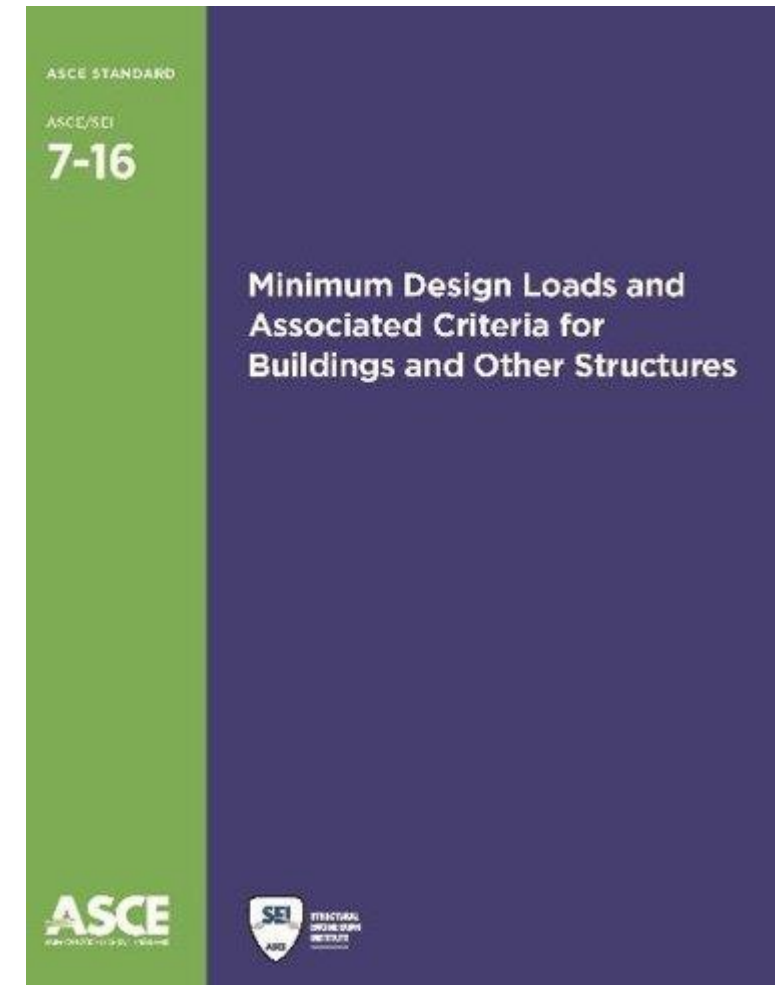
# Structural Safety



Shutterstock

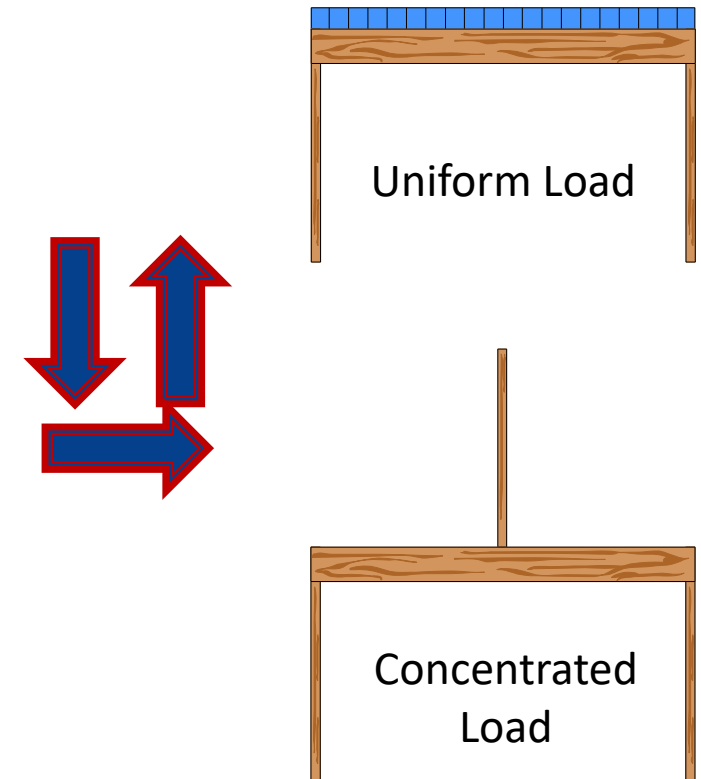
# Structural Design

- Loads determined per ASCE 7
- Risk categories based on building use
  - Category I
    - Agricultural and minor storage
  - Category II
    - Most common classification
  - Category III
    - Assemblies with occupant load >300 and hospitals without emergency treatment
  - Category IV
    - Hospitals with emergency treatment



# Basic Loads

- Gravity loads
  - Applied vertically down through a structure
- Uplift loads
  - Applied vertically up through a structure
- Lateral loads
  - Applied horizontally to a building
- Uniform loading
  - Applied equally across a structural member
- Concentrated load
  - Applied in a single location of a member
    - Example: column bearing in the middle of a beam



# Live Loads

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs.)
Dining rooms and restaurants	100	—
Office spaces	50	2,000
Residential 1- and 2-family dwellings		
Habitable attics and sleeping areas	30	
Other areas	40	—
Retail		
First floor	100	1,000
Upper floors	75	1,000
Stairs and exits		300
1- and 2-family dwellings	40	
All others	100	
Storage warehouses		
Heavy	250	
Light	125	
(must be designed for heavier loads if required for anticipated loads)		
Roofs		
Roof surfaces subject to maintenance workers		300
Ordinary flat, pitched and curved roofs	20	
Occupiable roofs	100	

[Ref. Table 1607.1]



# Dead Loads

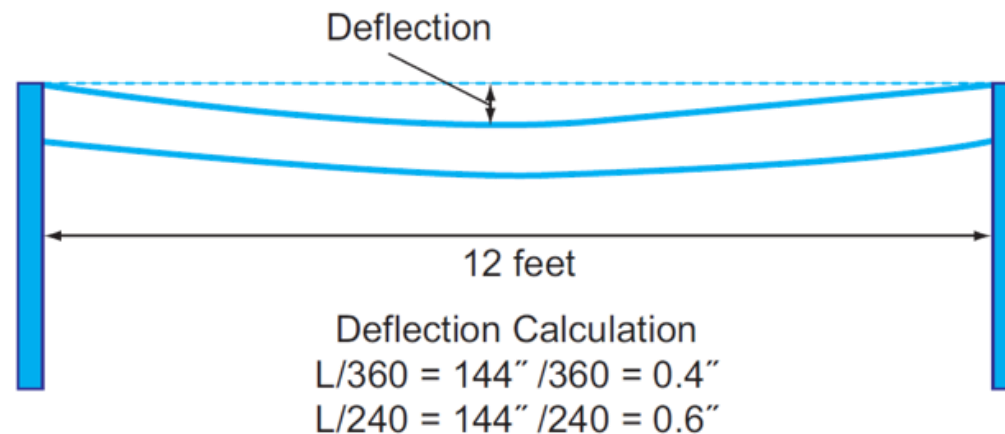
- Actual weight of construction materials
- Considered permanent loads

COMPONENT	LOAD (psf)
Double wood floor supported on 2 x12 joists 16 inches on center	7
Hardwood flooring, $\frac{7}{8}$ -inch	4
Linoleum tile $\frac{1}{4}$ -inch	1
Wood stud walls with $\frac{1}{2}$ -inch gypsum board each side	8
$\frac{5}{8}$ -inch gypsum board ceiling	3
Asphalt shingles	2
[Ref. Table C3.1-1a of ASCE 7]	

# Deflection

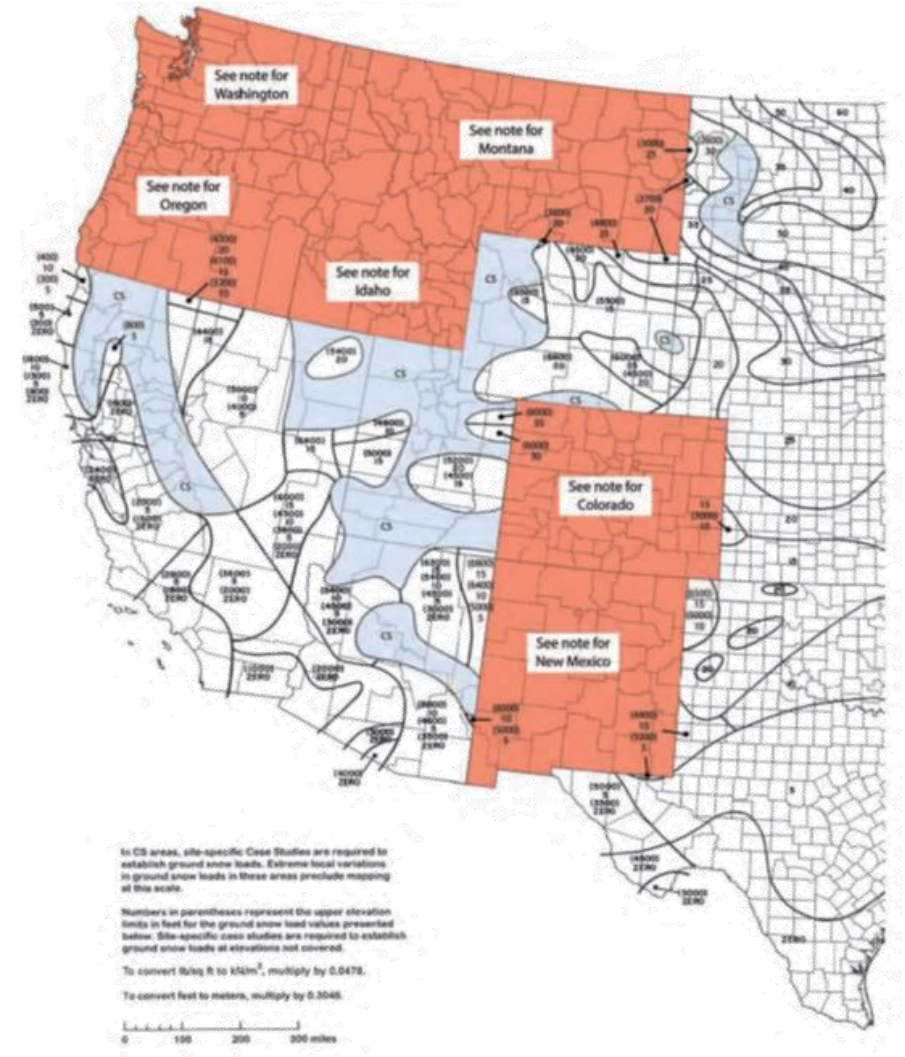
CONSTRUCTION	MAXIMUM DEFLECTION UNDER		
	Live Load	Wind or Snow Load	Dead + Live
Roof members:			
Supporting plaster or stucco ceiling	$l/360$	$l/360$	$l/240$
Supporting nonplaster ceiling	$l/240$	$l/240$	$l/180$
Not supporting ceiling	$l/180$	$l/180$	$l/120$
Floor members	$l/360$	—	$l/240$
Exterior walls:			
With stucco or plaster finishes	—	$l/360$	—
With brittle finishes	—	$l/240$	—
With flexible finishes	—	$l/120$	—

[Ref. Table 1604.3]



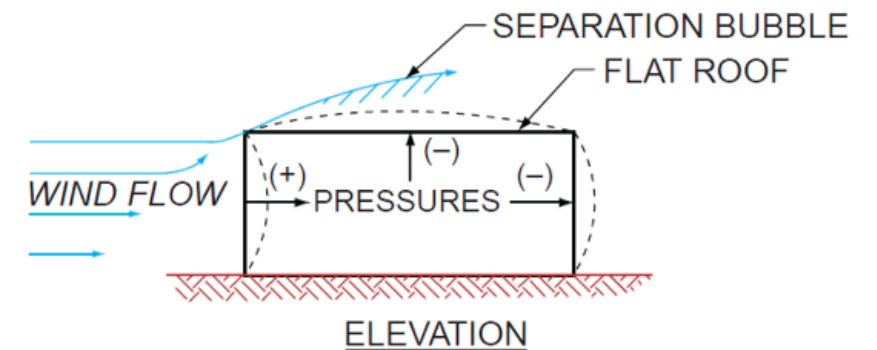
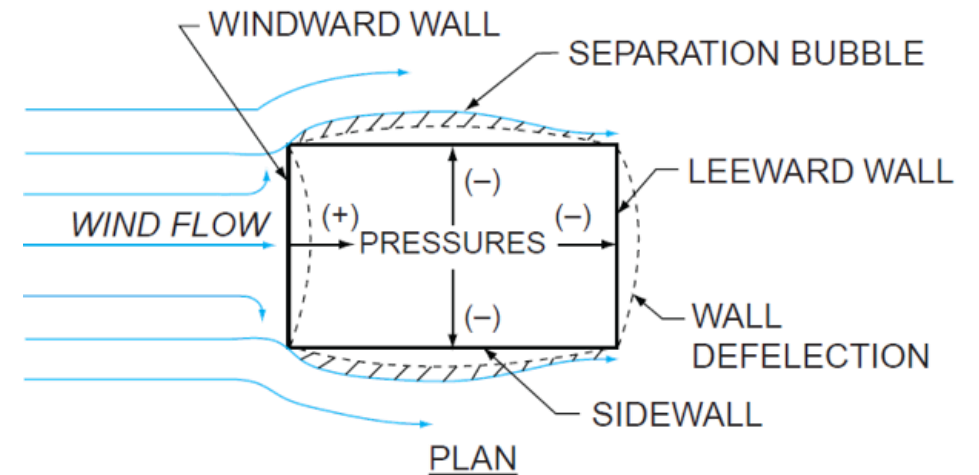
# Snow Loads

- Ground snow loads
- 'CS' = case study
- Elevation influence
- State-specific tables
- Drifts and sliding must be considered




# Wind Loads

- Typically lateral and uplift loads
- Positive and negative pressures
- Based on wind speed
- Affected by surface roughness and exposure



# Earthquake Loads

- Based on severity of site's design earthquake ground motion
  - Seismic design categories
    - A , B, C, D, E, F
- Low  High
- Design per ASCE 7





# Flood Loads

- Methods to determine flood hazard areas
  - >1% chance of flooding annually (100-yr flood plain)
  - Designated on community flood hazard map
- FEMA Flood Insurance Rate Map (FIRM)



# Soils

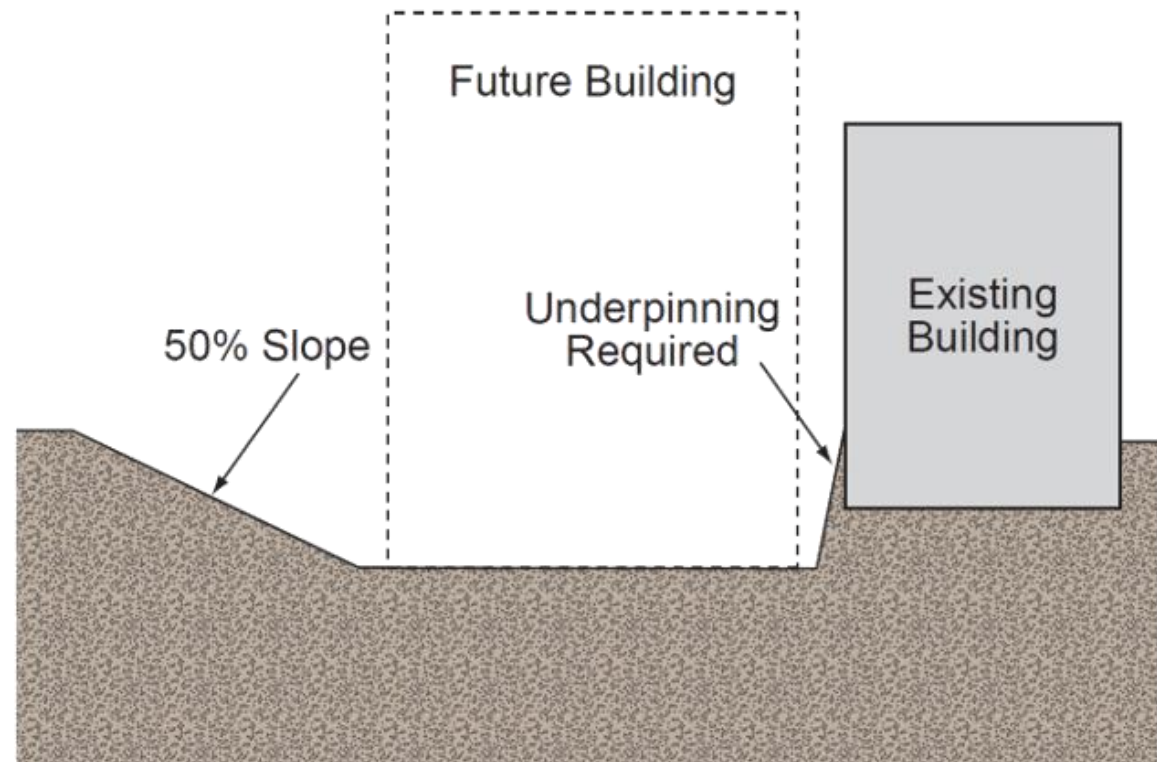
- Unified soil classification
- Building official can require a geotechnical investigation
  - Drilling into the ground and taking samples
  - Digging test pits
  - Evaluate
    - Soil strength
    - Bearing capacity
    - Effects of moisture
    - Compressibility
    - Liquefaction
    - Expansiveness





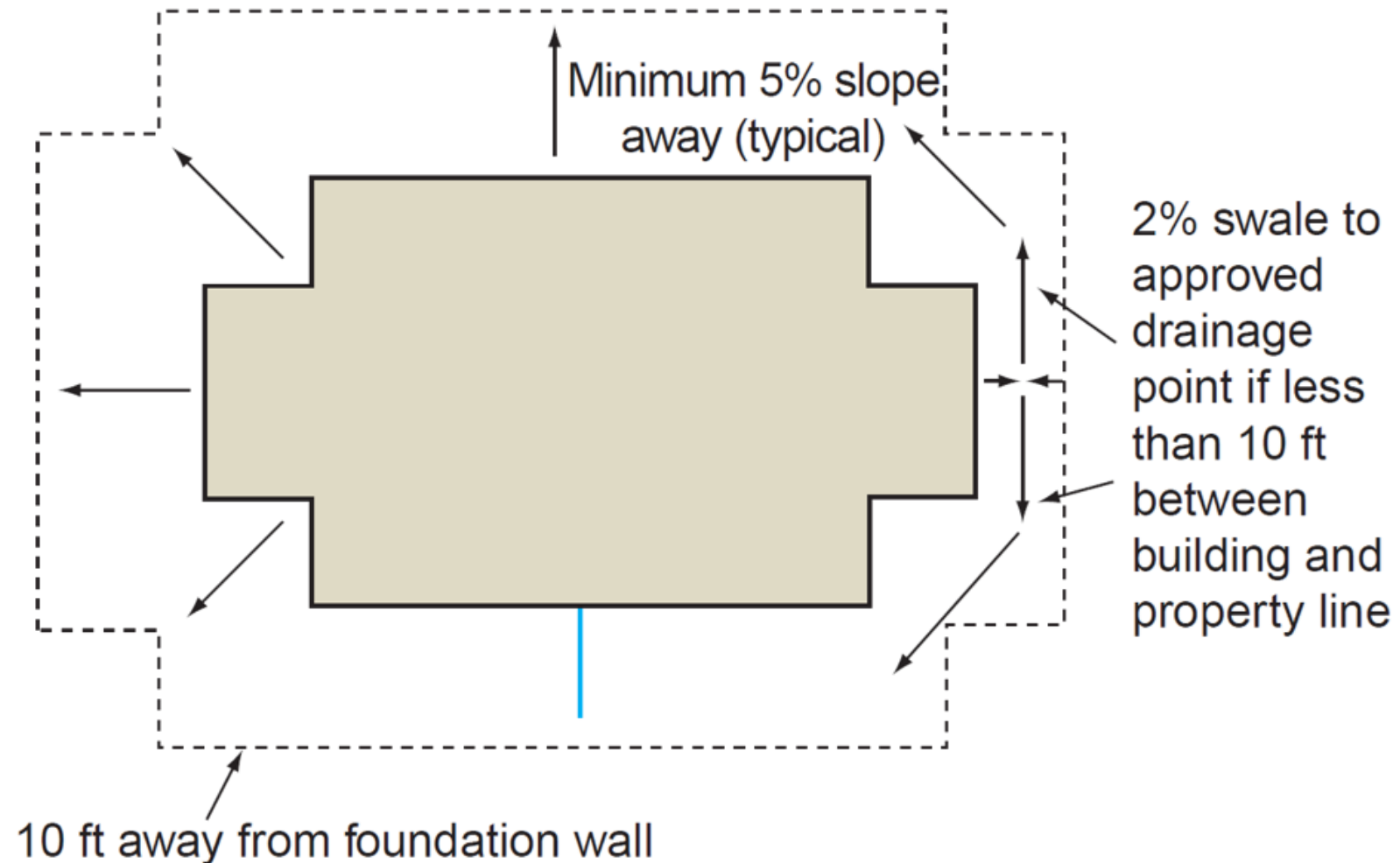
# Excavation

- Proximity to existing structures may require underpinning
- Excavation slope controlled so dirt does not fall into the hole
  - 1:2 (50% slope)



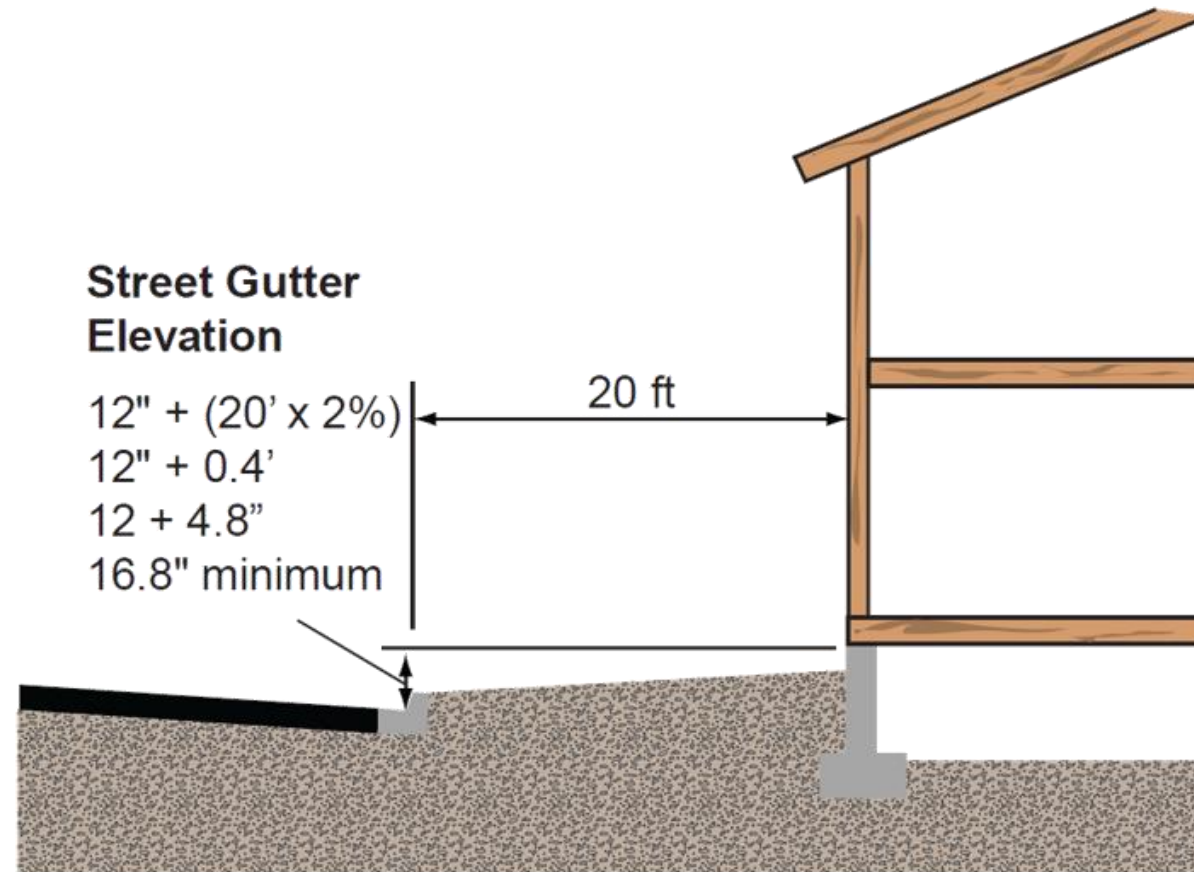
# Grading

## Positive drainage away from buildings



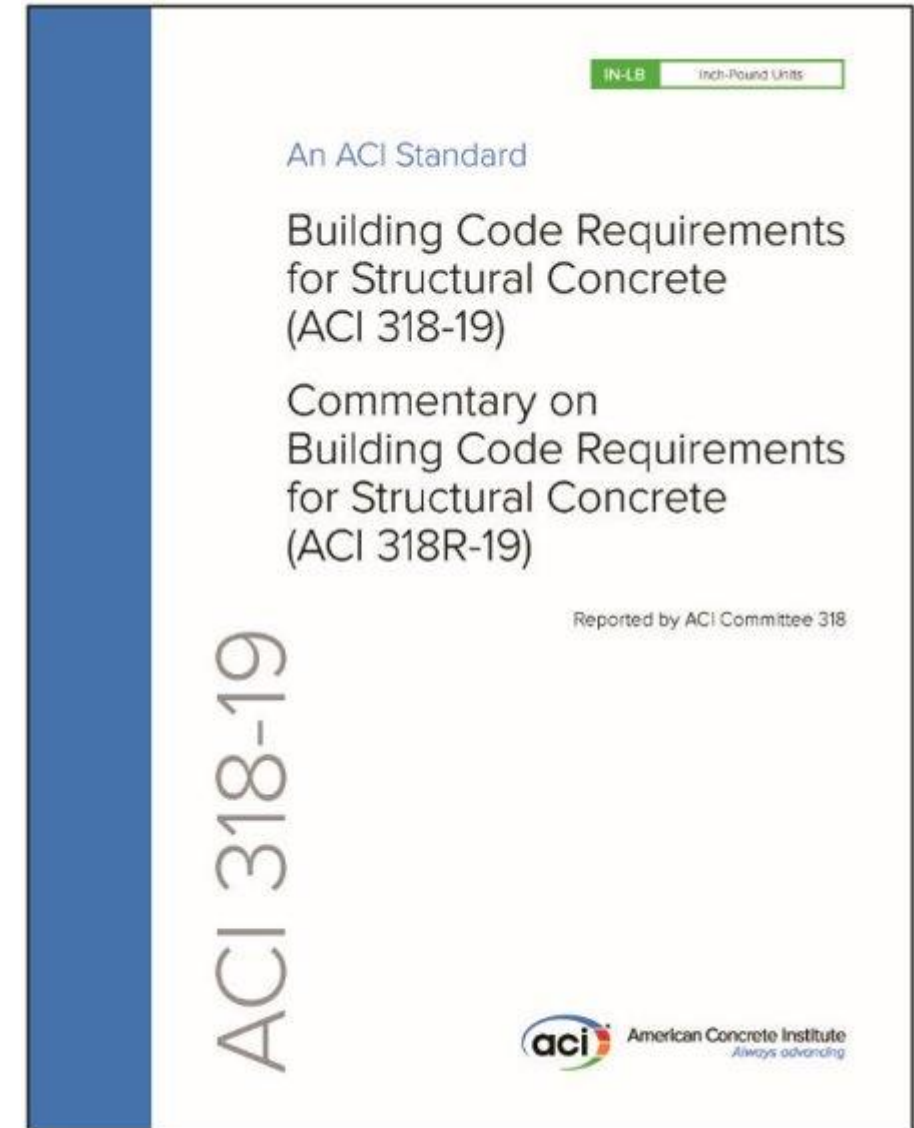
# Grading

Foundation must be 12" + 2% above street gutter



# Concrete Construction

- Concrete is a mixture of cement, aggregate, and water
- American Concrete Institute's (ACI) Standard 318 Building Code Requirements for Structural Concrete
  - Code-referenced standard
- IBC Chapter 19 contains additional requirements and amendments to ACI 318



# Concrete Durability

## Exposure categories

- F – Moisture and freezing/thawing and deicer chemicals
- S – Sulfates in water or soil
- W – Water where concrete is intended to have low permeability
- C – Moisture and chlorides from (or spray from these sources)
  - Deicing chemicals
  - Salt
  - Brackish water
  - Seawater

Moisture and Freeze/ Thaw Exposure Category	Structural Concrete ACI 318-19 Table 19.3.2.1	Nonstructural Concrete IBC 1904
F0	2,500	2,500
F1	3,500	3,000
F2	4,500	3,500
F3	5,000*	3,500

\*Plain concrete minimum compressive strength is 4,500 psi.

# Concrete Foundation Walls

- Prescriptive or engineering
- Seismic Design Categories C, D, E and F
  - Typically require RDP
- Wall thickness and steel reinforcement based on lateral loads
- High lateral loads require engineering



# Concrete Formwork

- Designed, fabricated, erected and removed in accordance with ACI 318
- Substantially tight to prevent leakage of concrete
- Properly braced
- Remain in place until cured or shored





# Concrete Steel Reinforcement

- Resists tension, or pulling apart, when concrete is subjected to loads
- Vertical and/or horizontal rebar may be required



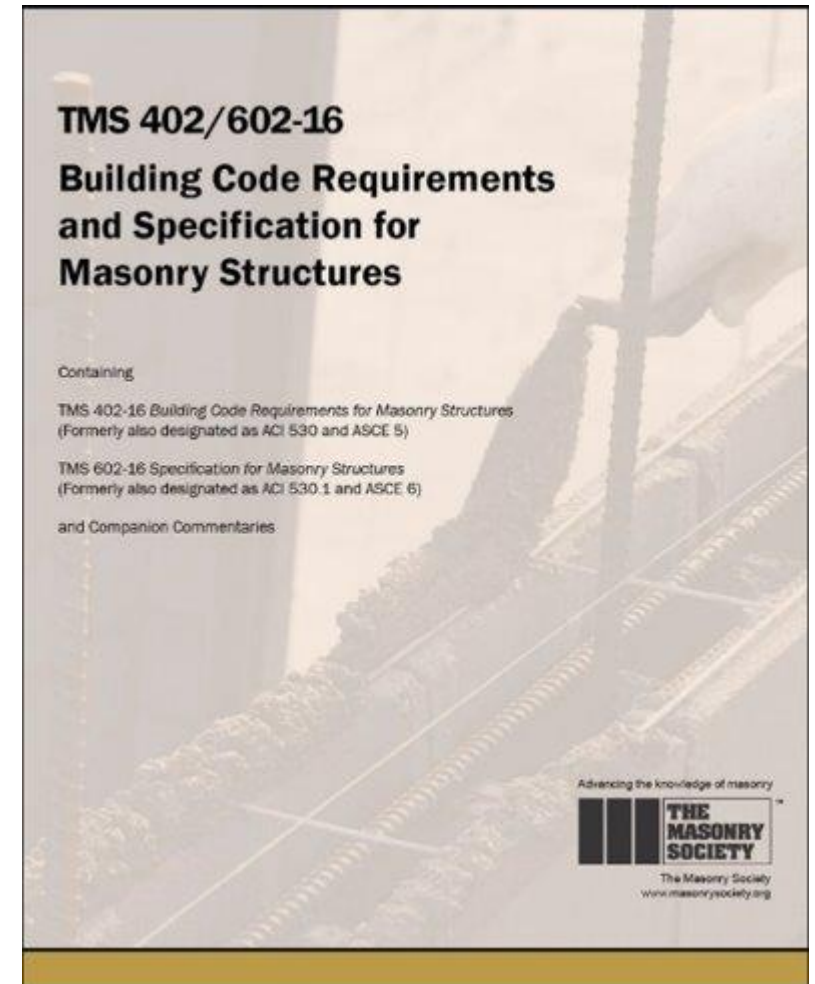
# Concrete Special Inspection

- Quality has direct relationship to strength
- Inspection by special inspection agency – with some exceptions
- Continuous inspections
  - Full-time observation of work
- Periodic inspections
  - Part-time or intermittent observation of work
- ASTM Standard C172 Practice for Sampling Freshly Mixed Concrete



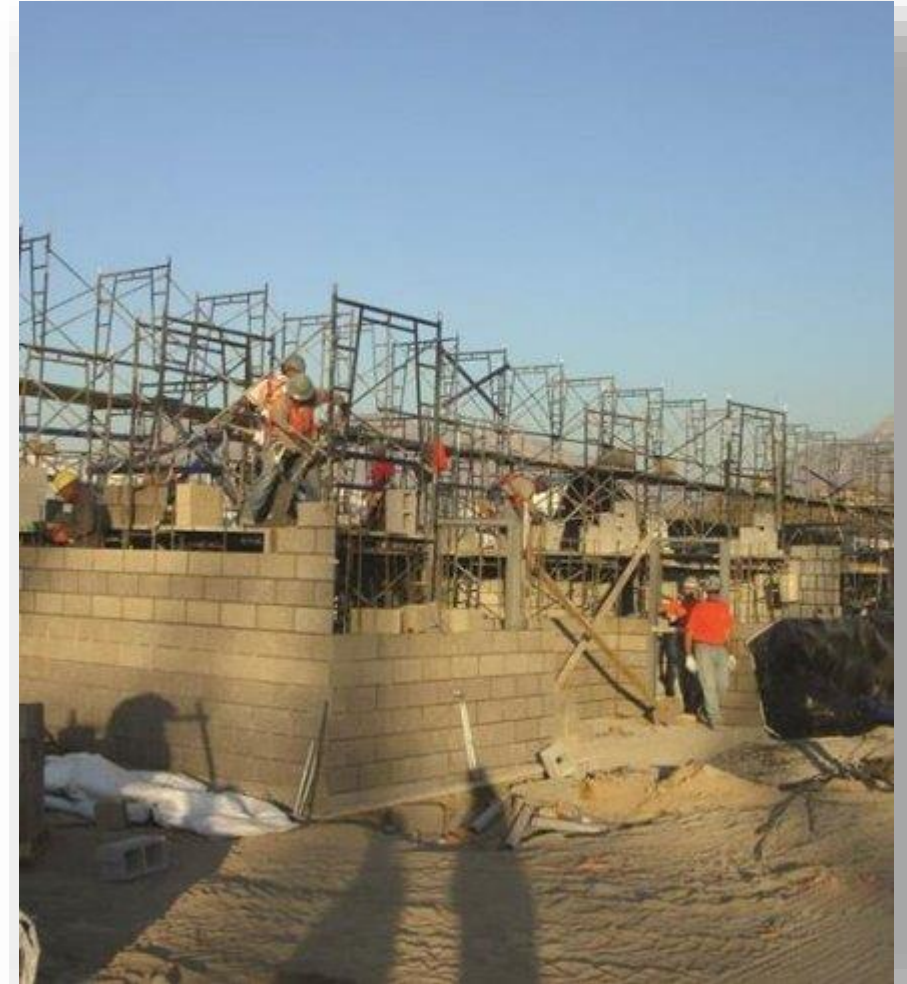
# Masonry Construction

## TMS 402/602 Building Code Requirements and Specification for Masonry Structures



# Masonry Foundation Walls

- Thickness determined by lateral loads
- Steel reinforcement typically required
- Cells of hollow or solid masonry units often grouted





# Masonry Materials

- Concrete, clay or shale, stone, AAC, and glass
- Bonded with mortar
- Grout
  - Fine
  - Course
- Steel reinforcing per TMS 602



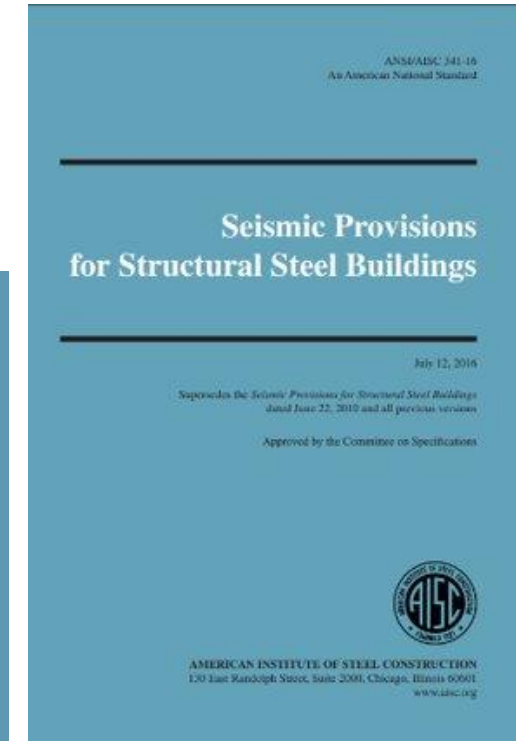
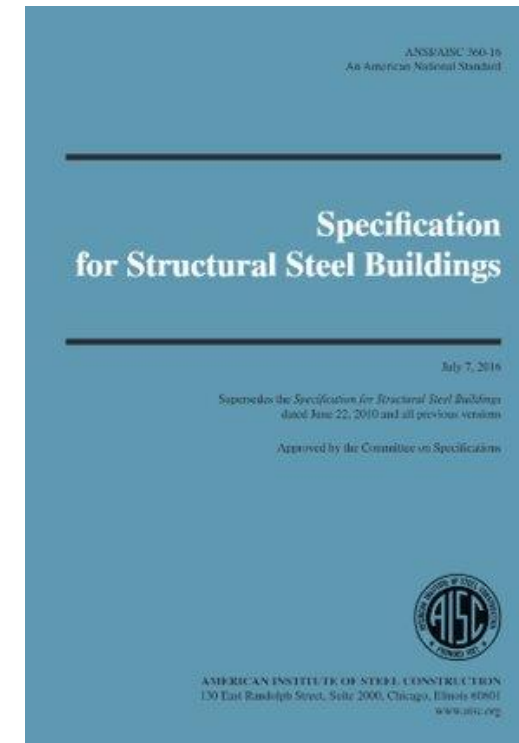
# Masonry Special Inspections

- Level I, II or III quality assurance
  - Risk Category
  - Designed or prescriptive
- Testing
  - Unit strength
  - Prism



# Steel Construction

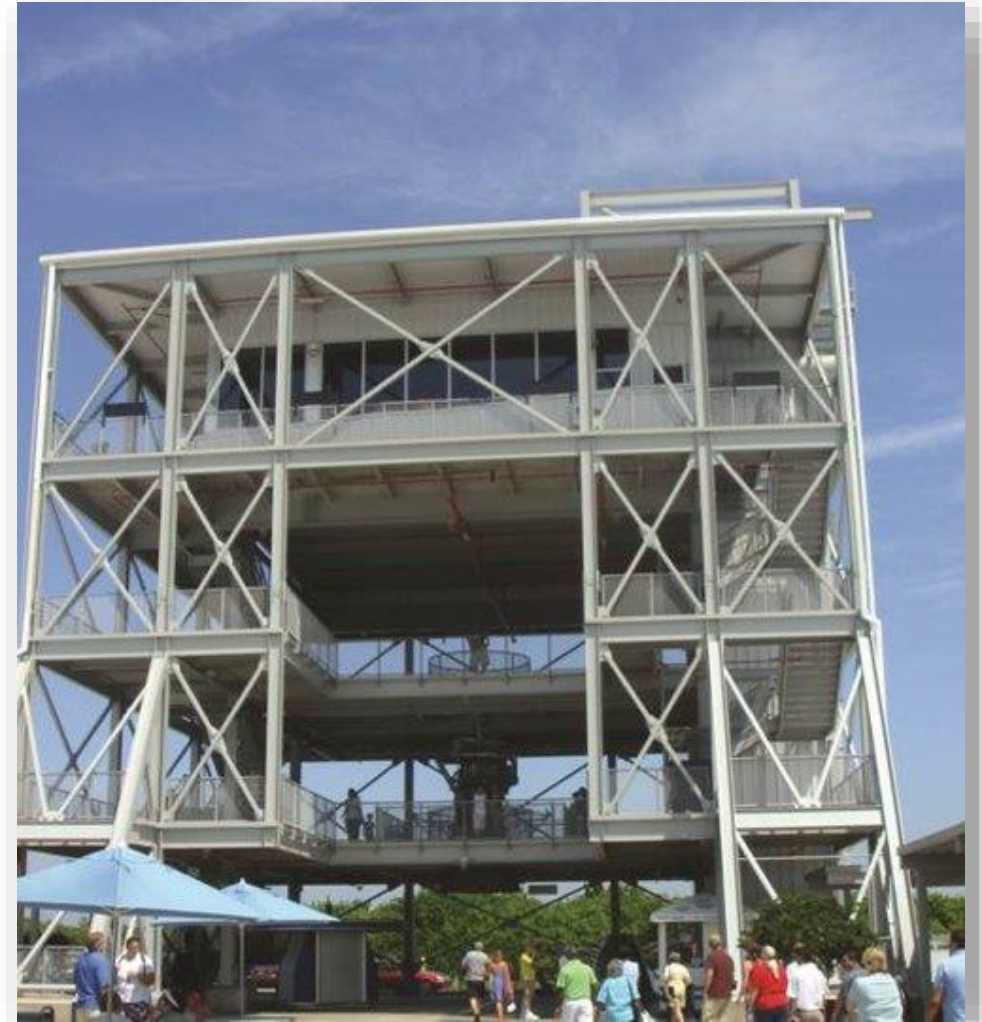
- American Institute of Steel Construction (AISC)
  - ANSI/AISC 360 Specification for Structural Steel Buildings
  - ANSI/AISC 341 Seismic Provisions for Structural Steel Buildings





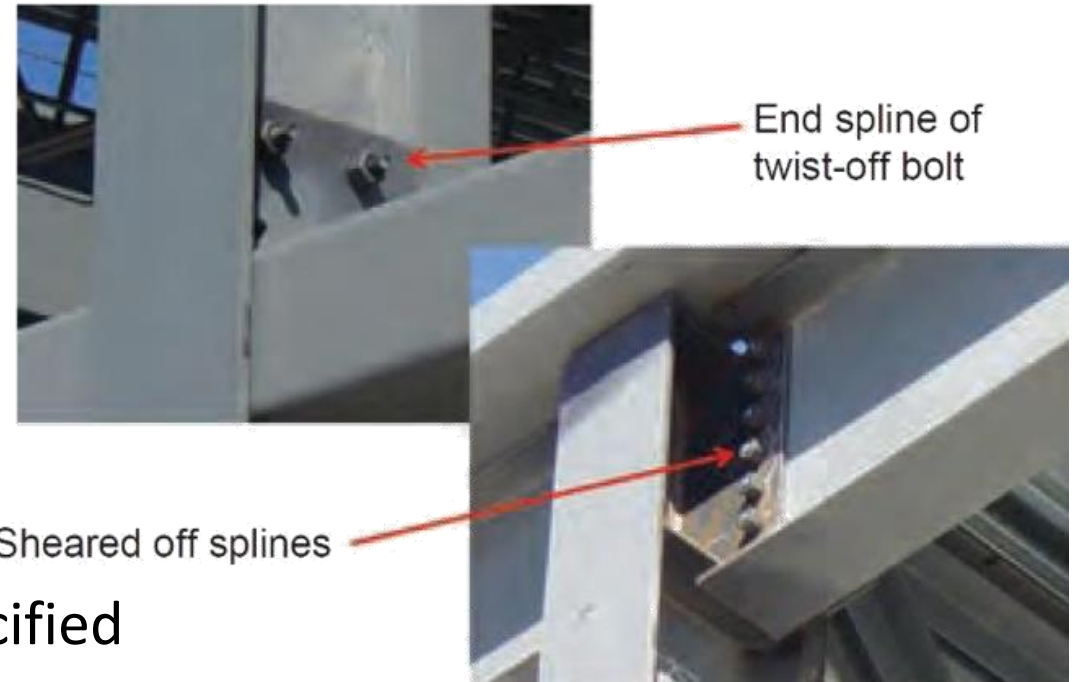
# Protection of Steel

- Approved coating to protect from corrosion
- If scratched or chipped during erection
  - Approved paint or primer
  - SFRM
    - Bare steel
    - Approved primer
    - Often unprimed for better adhesion of fireproofing



# Steel Connections

- Welding or bolting
  - Both require special inspections
- Bolted joints
  - Snug-tight
  - Twist-off
  - Slip-critical
    - Resist movement by friction
- Pretensioned
  - High-strength bolts tightened to specified minimum



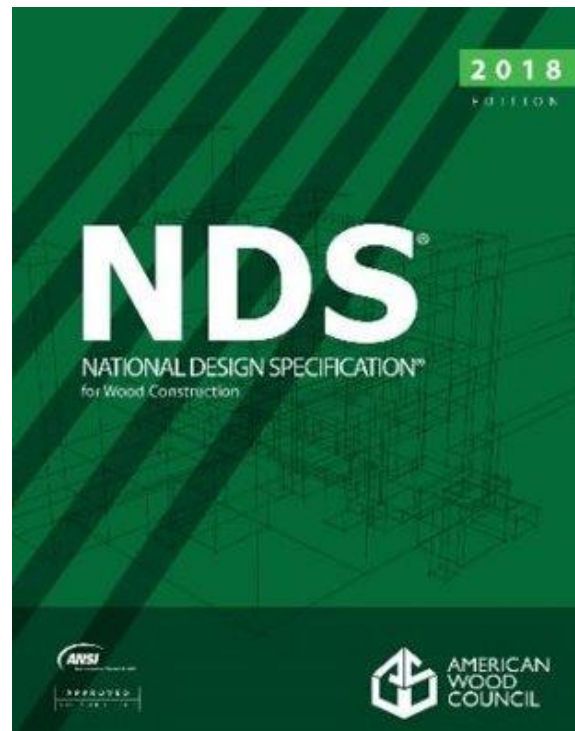
# Steel Special Inspections

- Connections
- Steel frame
  - Verify bracing, stiffening, member locations, and joint details at each connection
- Steel joists and girders
  - Inspection at fabrication facility
  - Approved fabricator

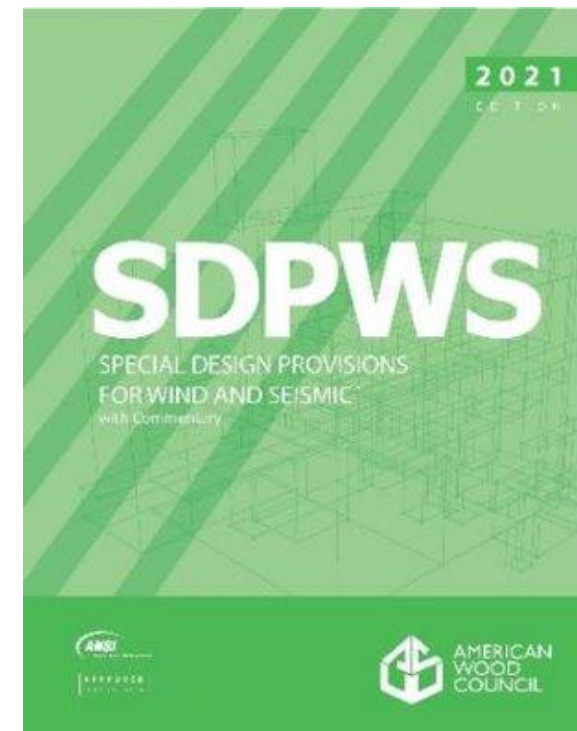


# Wood Construction

National Design  
Specification® (NDS®) for  
Wood Construction



Special Design Provisions  
for Wind and Seismic





# Wood Construction

- Conventional light-frame
  - Primary structural elements created by repetitive wood framing members
- Mass timber
  - Large-dimensioned wood members as structural elements



# Protection of Wood

Protection from moisture and insects

- Naturally durable wood
- Preservative-treated wood



Wood post on  
metal pedestal 1"  
above concrete



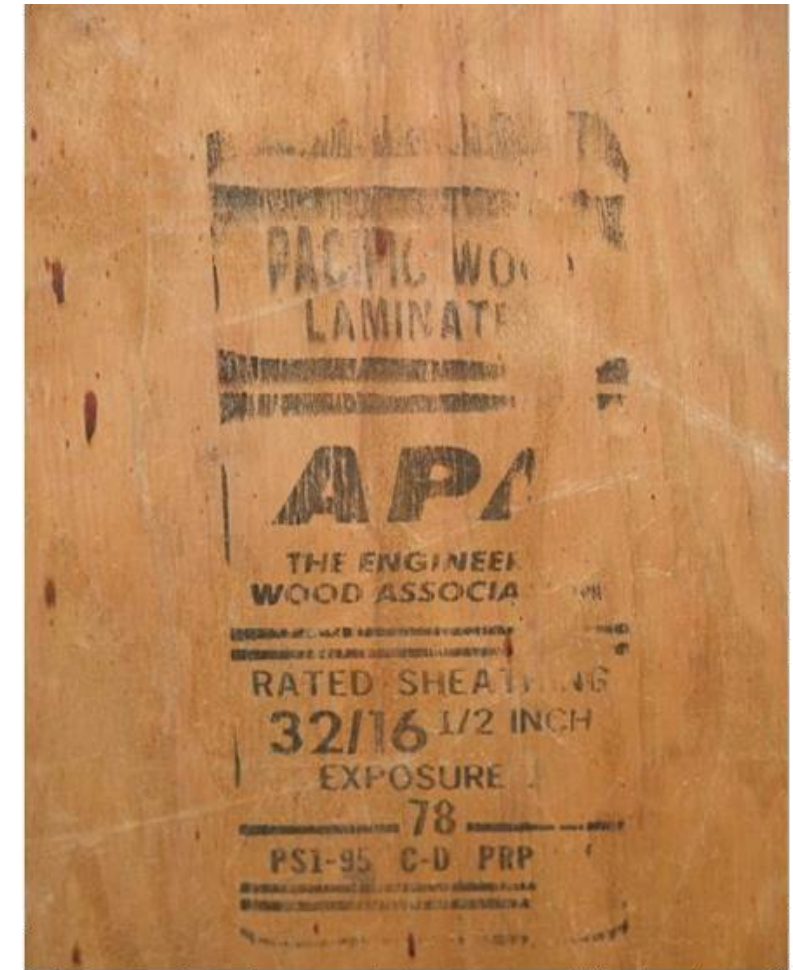
Preservative-treated  
wood or >8" above grade

# Grade Marks

- Required for
  - Lumber
  - Wood structural panels
  - Engineered wood products
  - Treated products



Lumber Grade Mark

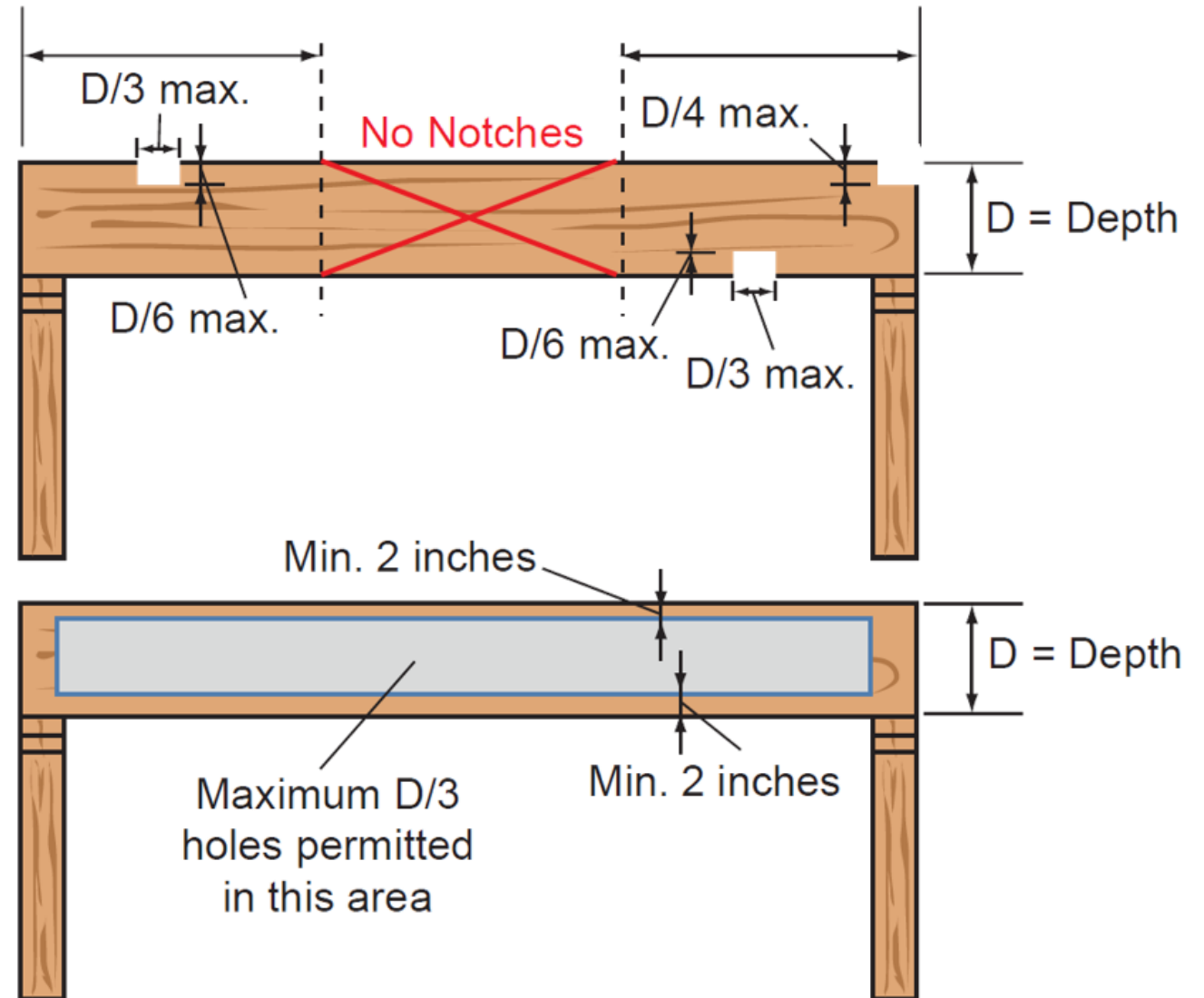


Wood Structural Panel Mark

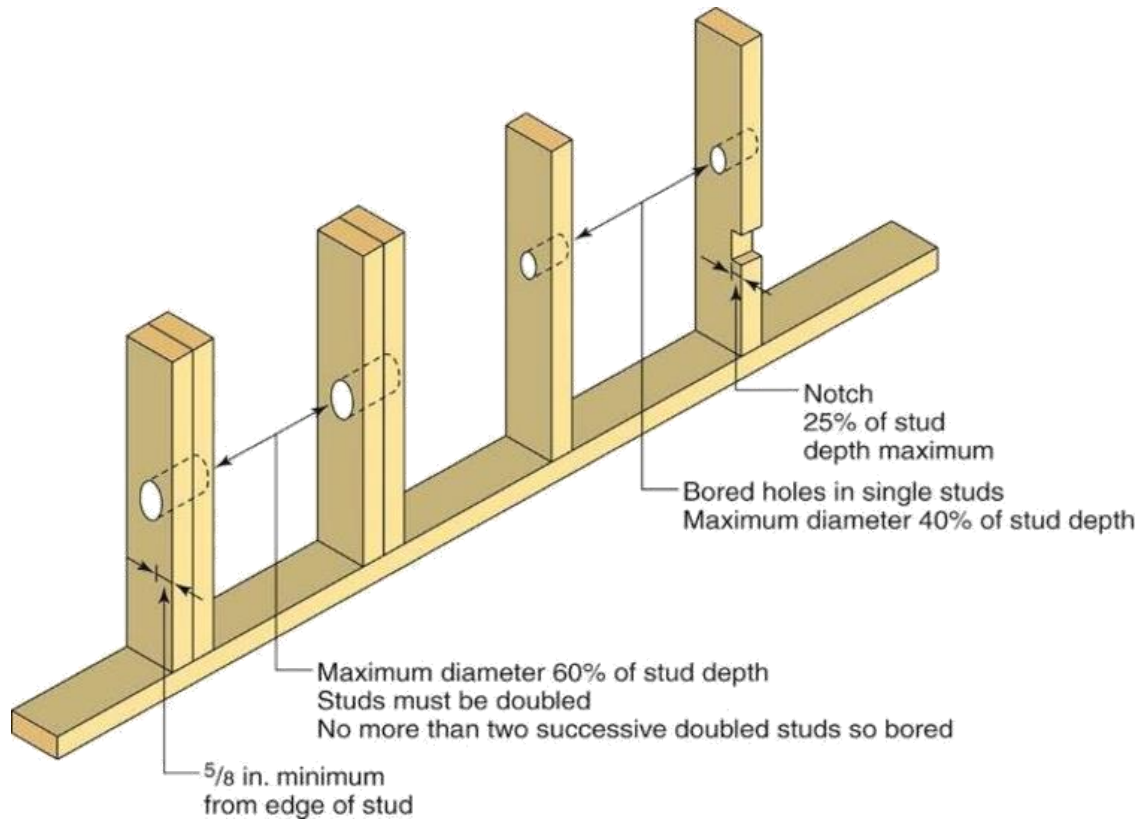


# Notching and Boring

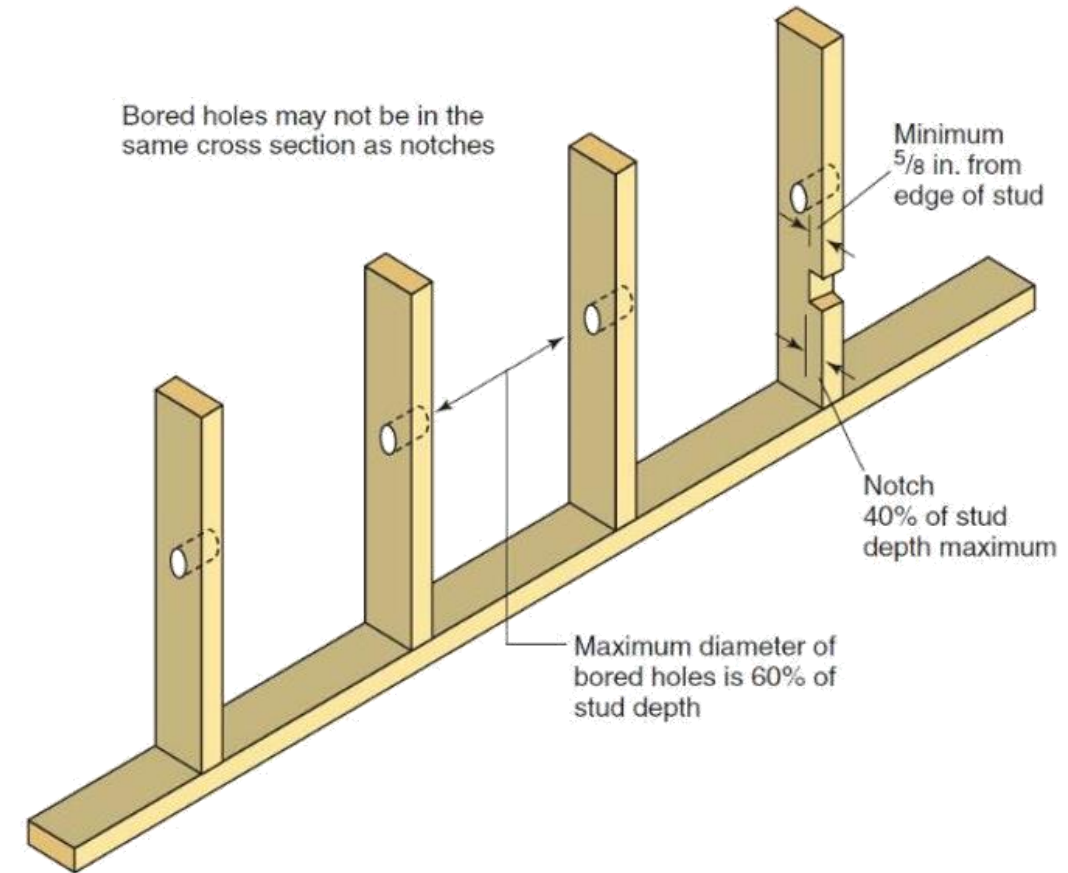
- Joists and rafters
  - Notches
  - Holes



# Notching and Boring



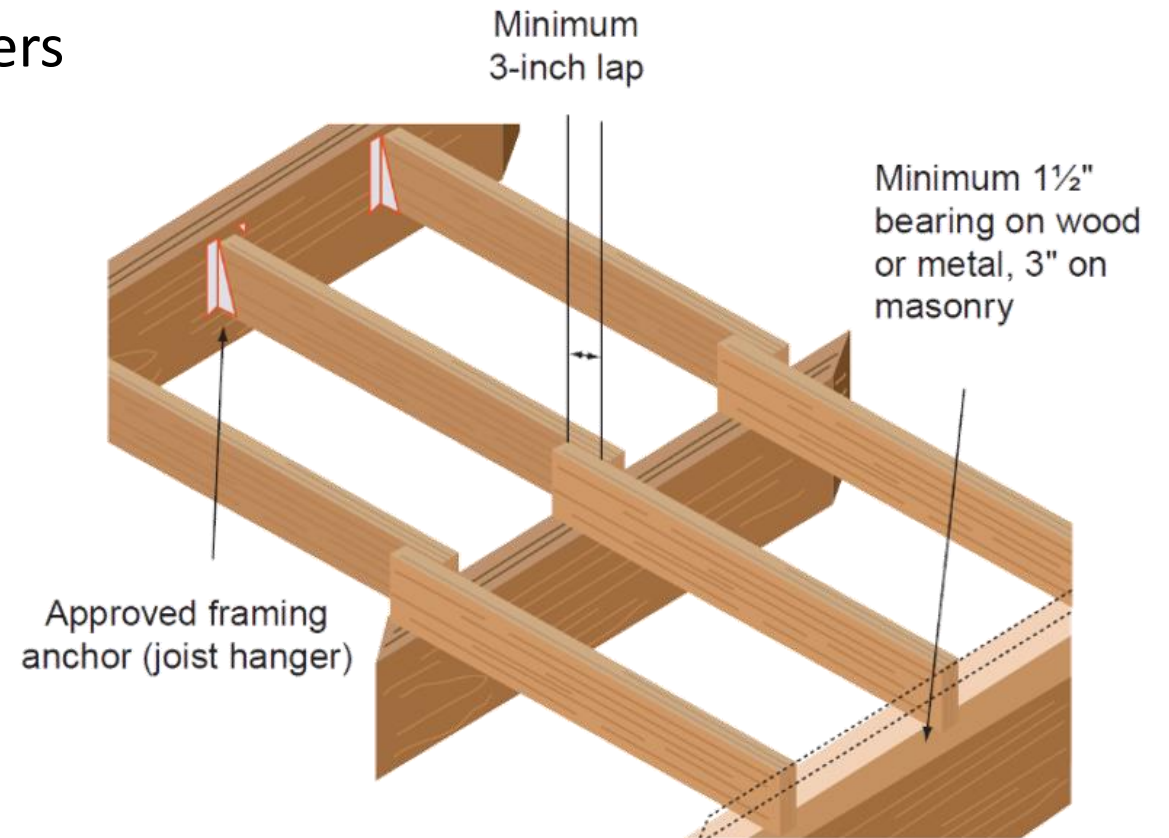
Bearing Wall



Non-bearing Wall

# Floor Construction

- Joist span tables for common wood species
- Other species
  - Span Tables for Joists and Rafters



# Allowable Floor Joist Spans

Determine minimum joist size: Hem-Fir #2, 16" o.c.,  
15' span, 30 psf live load, 10 psf dead load

JOIST SPACING (inches)	SPECIES AND GRADE	LIVE LOAD = 30 psf DEAD LOAD = 10 psf			
		2 × 6	2 × 8	2 × 10	2 × 12
		Maximum Floor Joist Spans (ft-in)			
16	Douglas fir #2	10-9	14-1	17-2	19-11
	Hem fir #2	10-0	13-2	16-10	19-8
	Southern pine #2	10-3	13-3	15-8	18-6
	Spruce-pine-fir #2	10-3	13-6	17-2	19-11

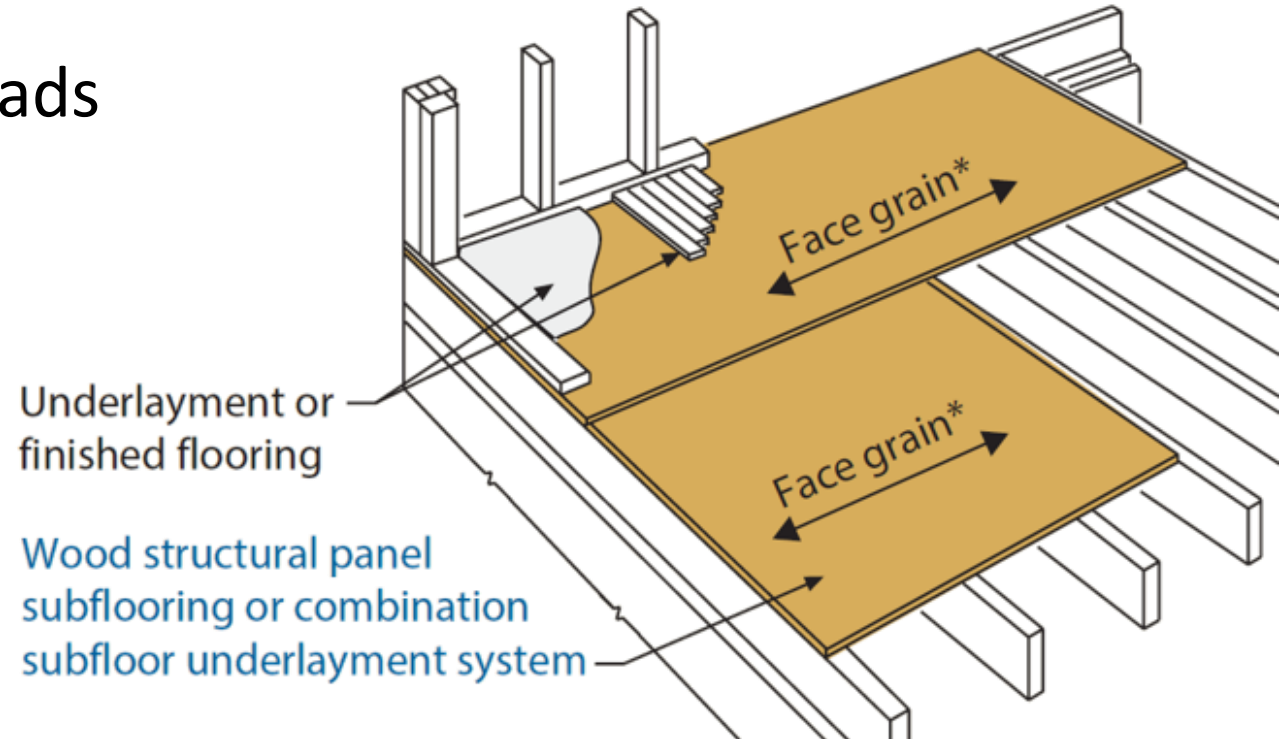
*For Example*

# Floor Sheathing

- Designed for expected loads
- Most common
  - Wood structural panels
- Example
  - $\frac{3}{4}$ " WSP, 48/24 rated

Roof sheathing span

Floor sheathing span



# Walls

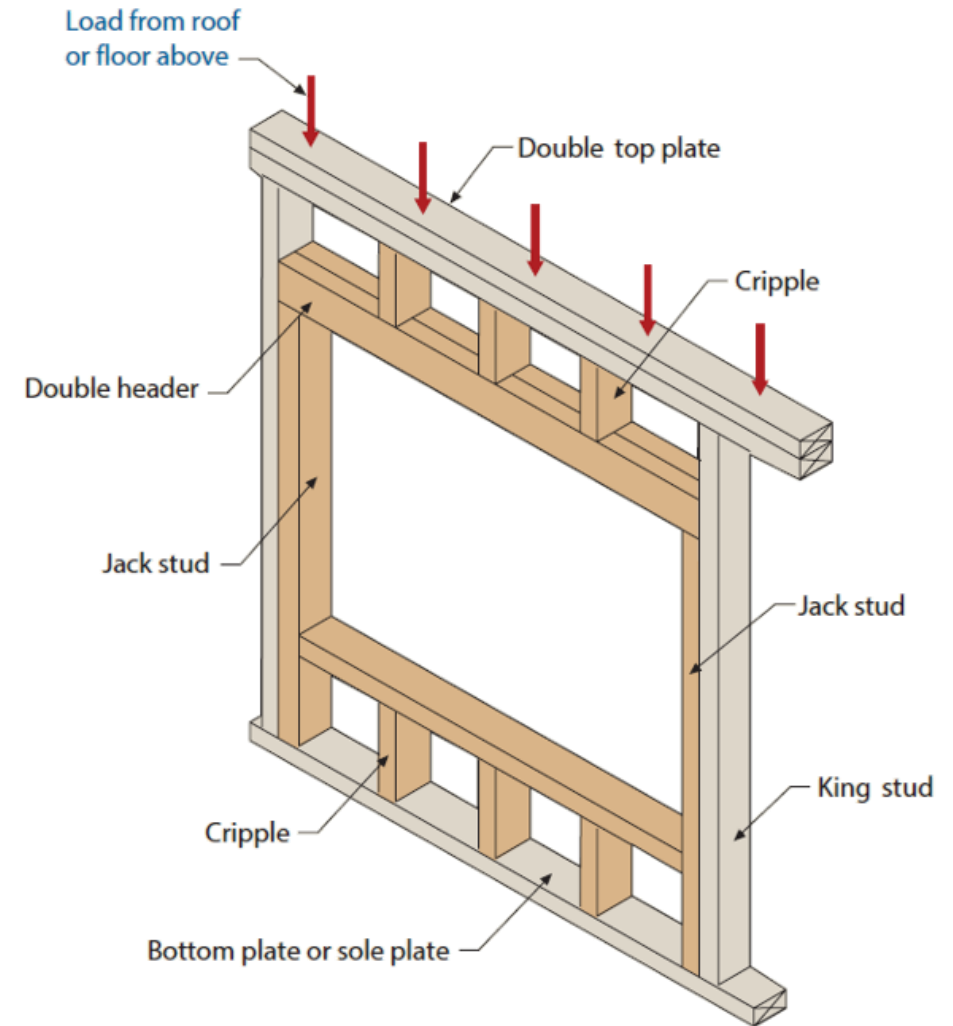
- Studs
  - Widest dimension perpendicular to wall
  - Continuous from bottom to top plates
  - Minimum 3 studs each exterior wall corner
- Top plates
  - Doubled in exterior and bearing walls
  - Overlapped at corners and partition intersections

STUD SIZE (inches)	BEARING WALLS				NONBEARING WALLS	
	Stud Height (feet) <sup>a</sup>	Supporting Roof and Ceiling Only	Supporting One Floor, Roof and Ceiling	Supporting Two Floors, Roof and Ceiling	Stud Height (feet) <sup>a</sup>	Spacing (inches)
		Spacing (inches)				
2 × 4	10	24	16	NP	14	24
2 × 6	10	24	24	16	20	24

[Ref. Table 2308.5.1]



# Wall Framing

- Bearing wall openings require headers to support loads
  - Single-ply to 4-ply tabulated
  - Equivalent single solid members permitted





# Wall Bracing Methods

METHODS/ MATERIALS	MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA	
			Fasteners	Spacing
WSP Wood Structural Panel	$\frac{3}{8}$ " in accordance with Table 2308.6.3(2) or 2308.6.3(3)		Table 2304.10.2	6" edges, 12" field
GB Gypsum Board (Double Sided)	$\frac{1}{2}$ " or $\frac{5}{8}$ " by a minimum of 4' wide to studs at maximum of 24" o.c.		Section 2506.2 for exterior and interior sheathing: 5d annular ringed cooler nails ( $1\frac{5}{8}$ " $\times$ 0.086") or $1\frac{1}{4}$ " screws (type W or S) for $\frac{1}{2}$ " gypsum board or $1\frac{5}{8}$ " screws (Type W or S) for $\frac{5}{8}$ " gypsum board	For all braced wall panel locations: 7" o.c. along panel edges (including top and bottom plates) and 7" o.c. in the field

[Ref. Table 2308.6.3(1)]

# Ceiling and Roof Framing

Determine minimum rafter size: Douglas Fir-Larch #2; 16" o.c.; 14' span; ceiling attached; 30 psf ground snow load; 10 psf dead load

RAFTER SPACING (inches)	SPECIES AND GRADE	DEAD LOAD = 10 psf				
		2 × 4	2 × 6	2 × 8	2 × 10	2 × 12
		Maximum Rafter Spans (ft-in)				
16	Douglas fir #2	7-10	11-11	15-1	18-5	21-5
	Hem fir #2	7-3	11-5	14-11	18-2	21-1
	Southern pine #2	7-6	11-2	14-2	16-10	19-10
	Spruce-pine-fir #2	7-6	11-9	15-1	18-5	21-5

# Crawl Space and Attic Access

- Crawl spaces
  - Minimum 18" x 24" opening
- Attics with clear height >30"
  - Minimum 20" x 30" opening
- Clear headroom >30" above access opening
- Large enough to remove largest appliance



# Engineered Wood Products

- Prefabricated Wood I-joists
- Glued-Laminated Timber
- Cross-Laminated Timber
- Structural Composite Lumber
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)



Wood I-Joist

LVL Beam



# Trusses

- Floor and roof framing members
  - 2x4 up to 2x12
  - Typically fabricated with metal connector plates
- Installed per
  - Submitted truss drawings
  - TPI National Design Standard for Metal-Plate-Connected Wood Truss Construction



# Gypsum Board

- Provides a smooth finished surface
- Can provide passive fire protection
- Can provide lateral resistance
- Various types
  - Type X
  - Type C
  - Water-resistant



# Foam Plastics

## Foam plastic insulation

- Flame-spread index <75
- Smoke developed index <450
- ASTM E84 and UL 723

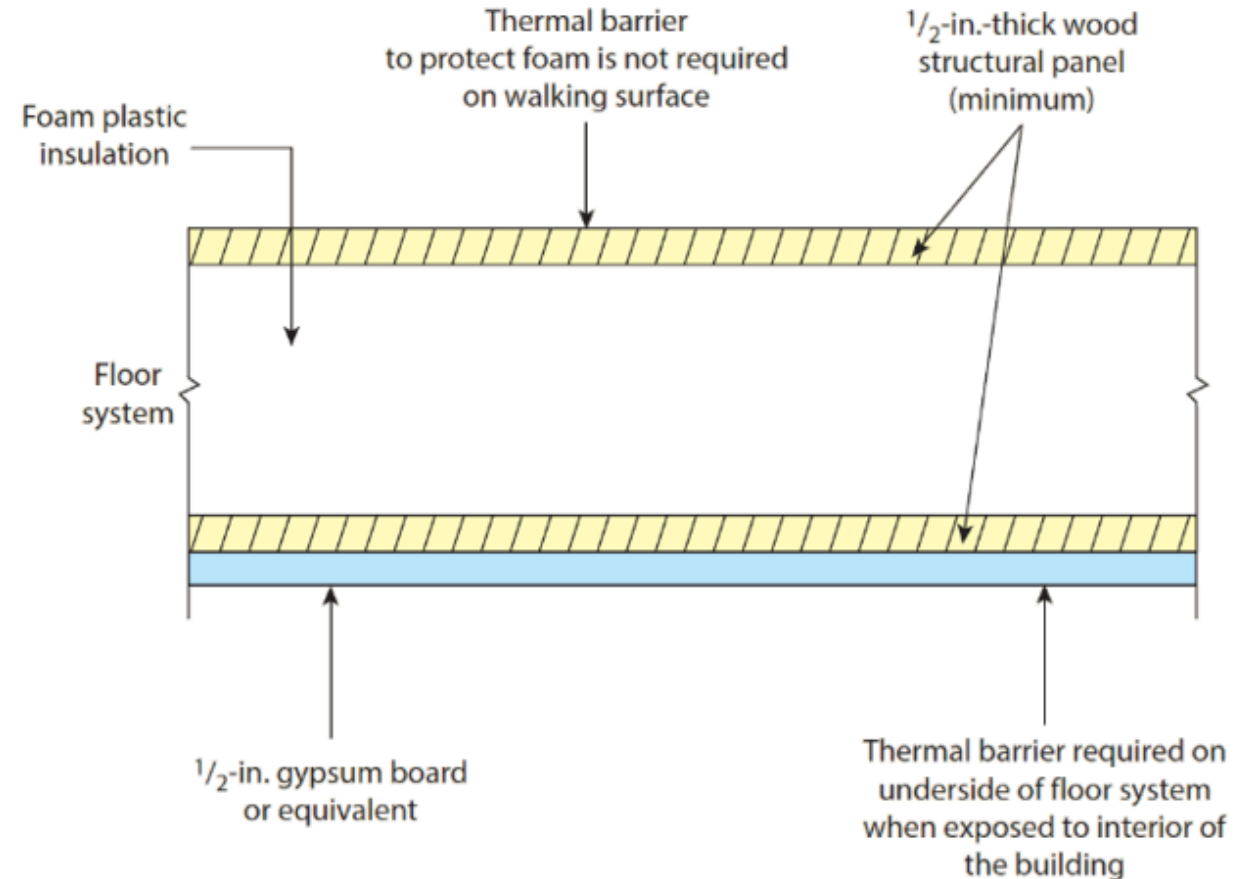




# Interior Foam Plastics

Separated by thermal barrier

- Single layer of ½" gypsum wallboard or equivalent
- Must remain in place for 15 minutes



# Interior Foam Plastic Trim

- Density  $>20$  pcf
- Thickness  $<\frac{1}{2}$ "
- Width  $<8$ "
- $<10\%$  of wall or ceiling area
- Flame-spread index  $<75$



# Poll Question

28. The 1st floor in a Group M retail store must be designed to carry a uniform live load of \_\_\_\_\_ psf.
- a. 50
  - b. 75
  - c. 100
  - d. 125



# Poll Question

29. When designing a building, each of the following loads are specific to the area where the building will be constructed except:
- a. Ground snow load
  - b. Live loads
  - c. Wind speeds
  - d. Seismic loads



# Poll Question

30. The ground must have a minimum slope of \_\_\_\_\_ percent for a minimum of 10 feet perpendicularly away from a building.
- a. 1
  - b. 2
  - c. 3
  - d. 5



# Poll Question

31. The exterior foundation of a building must be elevated to a point at least 2% plus \_\_\_\_\_ inches above the point of discharge.
- a. 6
  - b. 12
  - c. 15
  - d. 18



# Poll Question

32. Absolutely no holes or notches can be made in a 2 x 12 wood floor joist.
- a. True
  - b. False





# Poll Question

33. Foam plastic materials are prohibited as trim on the interior of a building.
- a. True
  - b. False



# Discussion



# Final Reflection

**What?** What was observed?

**So what?** What did you learn?

**Now what?** How will you do things differently on the job?



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